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Contents.

	PAGE
Forthcoming Events	317
First Fruits of Tariffs	317
Art in Industry	317
Correspondence	318
Notes from I.B.F. Branches	318
Random Shots	318
Crucible Furnaces	319
London Foundrymen visit Welwyn Garden City	323
Applying Foundry Technique to Spun Pipe Manufacture	324
Austenitic Cast Irons	325
Bengal Iron Company, Limited	327
The Shape of the Tensile Test-Bar for Cast Iron	327
Stalemate in Non-Ferrous Scrap	328
Brinell Hardness and Tensile Strength of Cast Iron	328
Iron and Steel Representatives for Ottawa	328
Foundry Opportunities in the West Indies	328
Babbitting Steel Shell Bearings	329
I.B.F.: Newcastle Conference	329
This Week's News in Brief	330
Trade Talk	330
Contracts Open	330
Personal	330
Obituary	330
Company Meeting	330
Company Reports	330
Raw Material Markets	332

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES' EQUIPMENT AND SUPPLIES ASSOCIATION.

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Forthcoming Events.

Institute of British Foundrymen.

JUNE 7-10.

Institute of British Foundrymen:—Twenty-ninth Annual Conference at Newcastle-on-Tyne.

First Fruits of Tariffs.

A short time ago a daily paper printed a short statement which gave in detail the state of the times in which we live, and then revealed that it was written over a hundred years ago with reference to an earlier crisis which was met and in due course overcome. The reflection occurred to us in coming casually across the following paragraph: "——'s neighbours have ceaselessly taken steps to raise tariff barriers. In spite of these commercial treaties which she has signed with them, she sees door after door closed on her products, whilst they invade her country with even larger and more numerous imports, against which her tariffs, becoming more and more inadequate, cannot operate." That describes the position of Great Britain a few months ago admirably. It could not be more apt and to the point. Yet it was not said of this country, but by a well-known French founder, an article from whom we published early in the present year, about France. The experience is, of course, universal, as even America is finding out to her cost, and the British action in imposing tariffs should at least show other countries that the tariff race is fundamentally unsound. The first results of the import duties are quite acceptable. There has been no appreciable rise in prices. Imports have fallen, exports have risen, and hence the trade balance is improved. So far, so good. Our own published statistics relating to imports and exports of cast iron bear this out.

There is less tendency as a consequence to argue the case for or against a tariff on theoretical grounds and to wait and see if it works. In the meantime experts are coming round to the view that it was not Britain that slipped off gold, but that no longer could a reasonably stable currency follow what have been called the crazy antics of gold, tied up as the bulk of it is, absolutely sterile, in the vaults of two countries. The tendency, in fact, is to insist on the importance of stable commodity prices, the slump in which is responsible for so much trouble in the financial and industrial worlds to-day. It is felt that even if sterling were definitely fixed in terms of gold, say at 15s., even if not at par, it would not be fixed in terms of commodity prices. Yet any scheme to render commodity prices stable would quite definitely revolutionise business. In fact, a great deal of business activity depends on and is stimulated by slight changes in values, which are reflected in fluctuations of prices in materials. It is fairly certain, however, that never again will the Bank of England bind itself to convert notes into gold, of which commodity not sufficient exists for the purpose.

Art in Industry.

Last Tuesday, the Board of Trade published the Report it received on Art in Industry from the committee which has been sitting under the chairmanship of Lord Gorrell. Evidence was taken from a number of bodies and individuals of widely separated activities; *the foundry industry, however, was not officially represented.* Amongst the committee's recommendations is one calling for the establishment of a permanent body responsible for Exhibitions of Industrial Art with executive powers, whilst many other suggestions are put forward for the organisation of such exhibitions. As the foundry industry is often called upon to put many of the artistic touches to buildings, hardware, municipal purchases (park benches, lamp standards, etc.), and machinery, it should be officially represented on any committee subsequently established. To reap the major advantage from this new development, the foundry industry should press for the teaching of practical, *not* theoretical, foundry-work in the various art schools, in order that budding artists may learn the advantages to be derived from and limitations imposed by the utilisation of castings for artistic expression. They should know the range of colours yielded by the various alloys. They should be provided with tables showing the relative cost and the ease of casting of the alloys available, together with some notions as to the effect of exposure to atmosphere.

It has been insufficiently realised that for certain decorative schemes of small houses and flats, cast metallic wall-plaques have a proper and well-defined artistic sphere, but this class of buyer abhors the "Kiss Daddy" or "Lovers' Quarrel" type of art so popular in pre-war days. We possess some plaques of German origin of a filigree type which illustrate some of Hans Andersen's fairy stories, which display distinct artistic merit. Naturally, one hates this type of decoration to be mass-produced, but surely, by copyrighting, making only a limited number, and then destroying the pattern, values could be maintained, and pirating by moulders in their lunch hour prevented. This, however, is not what the committee had in mind. It assumed, for instance, that if the streets of a new housing estate have to be lit, the lamp standards might as well be made both artistic and utilitarian at but little extra cost. The committee no doubt is specially desirous that when a firm's engineers have turned out a first-class mechanical job, such articles shall not be at a disadvantage when shown in the shop windows of Calcutta, Buenos Ayres or Timbuctoo, through comparison with inferior but artistically-presented competitive materials.

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Wiltshire Brass Hardware.

To the Editor of The Foundry Trade Journal.

Sir,—May I trouble you to give me the names of some of the old brassfounders who make brass hardware in Wiltshire? About two hundred years ago a foundry in Wiltshire made the brass hardware for a house built in Virginia, and I understand, or at least it is said, they are still in business. I do not know whether they are located in Salisbury or which place in Wilts, as hardware cited does not give any name other than "Wilts." If you are unable to give me this information perhaps one of the old brass foundries can inform me where I may learn about the matter. Thanking you.—Yours, etc.,

I. Newton Lewis.

192, Broadway,
New York City, U.S.A.
May 16, 1932.

Tank Plates.

To the Editor of The Foundry Trade Journal.

Sir,—In your issue of April 21, 1932, "Jobbing Moulder" asks how certain tank plates could be cast straight. I would suggest that the runner is placed at the opposite end, and that two down runners are provided, connecting with two separate sprays the whole width of plate, cut to direct the metal stream along the sides of the mould, allowing the middle to fill last. The object is to obtain a more equal rate of cooling, which is not possible when a runner is placed at the heavy end. I would also suggest that he makes sure his metal has not excessive contraction, which in my experience is the cause of so much trouble.—Yours, etc.,

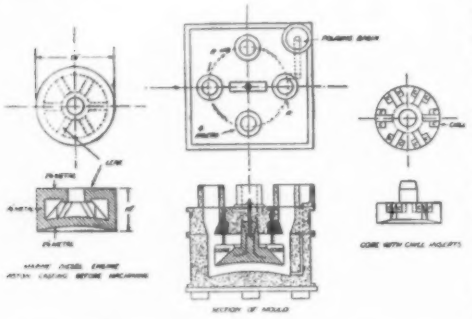
A. Bowman.

48, Lathom Road,
East Ham, E.6.

Diesel Engine Pistons.

To the Editor of The Foundry Trade Journal.

Sir,—A short while ago we received an order for six Diesel-engine pistons. One piston completed is composed of two castings, the part that carries the rings and the skirt that carries the piston-rod pin. The parts called for were those carrying the rings. The castings machined up clean, but four out of six leaked at 100 lbs. water pressure. The location of leak was at the



intersection of the bracket with body, as is shown in the accompanying sketch. The cupola charge for the two castings which withstood the test was made up as follows: 600 lbs. Dalzell No. 4, T.C., 3.58; Gr, 3.10; C.C., 0.48; Si, 1.85; Mn, 0.9; S, 0.05, and P, 0.3 per cent.; 360 lbs. machinery scrap, 240 lbs. boiler-plate castings.

The charges for the defective four castings were made from the following mixture: 600 lbs. Dalzell pig, 300 lbs. machinery scrap and 300 lbs. boiler-plate cuttings.

The feeding was done by hot metal from the cupola by means of hand-ladles. Referring to the sketch (section of mould), it will be noted that the core is suspended from the cope, and is held in position by six built-up box-chaplets bearing on core blocks rammed up in the cope.

Anticipating another order, we are thinking of making a change by making a one-piece cast-iron arbour for the core and dispensing with chaplets and inserting chills in the core, as shown. We would like to have your readers' advice on the cause of leaks and any other information on the matter.—Yours, etc.,

United Nail & Foundry Company, Limited.
J. Stowe, Foreman.

St. John's, Newfoundland,
May 4, 1932.

A Correction.

To the Editor of The Foundry Trade Journal.

Sir,—In the last issue of The Foundry Trade Journal and in the third column of page 312, I am reported as claiming to be "one of the four oldest members of the Institute" instead of "as one of forty oldest members," etc. I trust you will make this clear in your next issue, as I naturally do not wish this statement to be accepted as true.—Yours, etc.,

R. D. Welford.

1, Hilton Road,
Frizinghall, Bradford.
May 22, 1932.

Notes from I.B.F. Branches.

Newcastle and District Branch.—The Annual General Meeting of the Newcastle and District Branch was held on April 23, 1932, at the Neville Hall, Newcastle-upon-Tyne. The election of officers for next session took place, Mr. R. J. Shaw, Senior Vice-President, being made President; Mr. W. Scott, the present Junior Vice-President, becoming Senior Vice-President; and Mr. J. D. Carmichael, O.B.E., being elected Junior Vice-President. Mr. J. W. Eckford and Mr. J. N. Simm, honorary secretary and treasurer respectively, were re-elected; the lanternist, Mr. F. Spencer, was reappointed.

Messrs. C. H. Brown and James Lee were elected, on the motion of Mr. Frier, to fill the two vacant positions on the Council. Mr. W. Scott and Mr. J. N. Simm were elected as representatives to the General Council, and Mr. A. Logan and Mr. F. Allan were elected to the Technical Committee.

Mr. Allan announced that next session the nights on which the meetings were held were to be changed, and they would be held alternately on the last Saturday and Thursday of the month. The change was in the nature of an experiment, and they hoped eventually to discover on which night they could get the better attendance. During the past few months the slackness of work and unemployment among the members had been responsible for the falling-off in the attendance, but he believed that they would be able to obtain a larger attendance during the week than they sometimes could on a Saturday night.

In connection with the Conference to be held in Newcastle during the summer, Mr. Allan appealed for subscriptions, and said that although it was going to be a hard task, if everyone helped they hoped to make it very successful.

Particulars given by the Mannesmann Tube Works in Düsseldorf for the financial year 1931 show that the year closed with a loss of 916,016 mks., as against a profit of 14,260,000 mks. in the preceding year. The board proposes to cancel 5,400,000 mks. of the company's holdings of its own shares. The resulting book profit, 1,750,000 mks., is to be used for depreciation.

Random Shots.

Mention was made in this column recently of the new British film, "Steel." With characteristic originality of idea, "Marksman" ever since has been dallying lightly with the scenario of a proposed picture to be called "Iron." One of the big features of "Iron," as it is at present envisaged, is a Moulders' Chorus of 250 and a ballet of some sixty girl coremakers. In addition, several big-crowd scenes are included which require 800 supers. Following the bold lead of certain of the Continental producers, "Marksman" will insist that every part be taken, not by professional actors, but by ordinary human beings, whose connection with Cinema has only been to contribute to the box-office receipts. Thus it is hoped will "Iron" provide work and wages for some hundreds of unemployed members of the foundry industry.

* * *

A theme song, of course, will be essential. The syndicate necessary for its composition, "Marksman" suggests, should include, in addition to the usual group of composers and lyric writers, one or two practical foundrymen to act as "ideas men" and consultants. Naturally, the Moulders' Chorus would beat out the rhythm of the theme song with the aid of rammers. The actual story of the film has yet to be settled; but after a study of one or two twopenny novelettes of a suitably melodramatic character this should present no difficulty.

* * *

By the way, when the film is put into production—and it is bound to be taken up by one of our enterprising companies—a certain amount of equipment will be required. No doubt the cupolas, sand bins and the like will be run up by studio carpenters, but a few conveyors, ladles and even moulding machines will have to be purchased. Here is a business opportunity which equipment manufacturers should not overlook.

* * *

Miss Nelly Snookers has been languishing because of lack of publicity. She writes to "Marksman" as follows: "I am surprised that you have thought fit to neglect the excellent news-service provided by me through the Gayway Foundry at Eastbourne. I enclose herewith an item of news relating to the staff annual dinner, which I do hope you will be able to use at an early date." "Marksman" notes that the entire Gayway staff, numbering 120, attended the dinner, and, what seems to him to be truly remarkable, no less than 113 have completed fifty years' service with the firm. Each long-service member was presented by Miss Snookers with a box of hyacinth bulbs. Thus worthily is the loyalty of the Gayway staff accorded recognition. Following the dinner, dancing continued until midnight, when carriages were called.

Marksman.

Beryllium.—A. Stock, in a Paper before the American Electrochemical Society, states that the fused electrolyte process on which the large scale manufacture of aluminium and magnesium is based was not successfully applied to beryllium until very recently. This is due to the marked affinity of the metal for oxygen and carbon, and to its high melting point (1,300 deg. C.). The author used a mixture of beryllium fluoride and barium fluoride, operating the bath at 1,400 deg. C. Molten Be separates out at the water-cooled iron cathode. The extraction of beryllium from beryl is described briefly. For the quantitative estimation of Be in its ores, salts and finished products, a new analytical method was developed based on titration with chinalizarin. The interesting properties and uses of Be are discussed at length. A particularly important field of application are the beryllium bronzes.

Crucible Furnaces.*

By G. L. Cassidy, A.M.I.C.E.

Historical.

The art of smelting metals was probably discovered by the casual inclusion of copper-bearing ores in the stones forming a primitive fireplace. Whatever the truth of this, an open-shaft type of furnace was developed and used down to comparatively recent times. The disadvantages of such open-flame furnaces, in which the molten metal is necessarily contaminated by the fuel, must have been very apparent, and many attempts made to provide crucibles or other form of protection. Natural deposits of highly-refractory clay, occur in most parts of the world, able to withstand any temperatures likely to be obtained in a charcoal fire and sufficiently plastic to be thrown or moulded on the potters' wheel to the shape of a crucible. Unfortunately, crucibles made wholly of clay are what may be called "stunty," that is, they have not sufficient elasticity to withstand the stresses that occur in their material during temperature changes. These expansion and contraction stresses are very large, a typical example being the cracking of a thick glass tumbler when filled with hot water. The use of clay crucibles is therefore attended with considerable difficulty and only survived in one or two cases in which the protection of the charge was an absolute necessity, as in the crucible-steel trade of Sheffield and the calamine-brass process.

At Sheffield, by the exercise of a technique developed by generations of experience, tool steel has been melted in straightforward clay crucibles, temperatures of the order of 1,550 deg. C. being regularly obtained. Despite the great care taken, only three or four heats could be obtained from each crucible while early failures were common. To-day practically all crucible tool steel is melted in plumbago crucibles, which will give a dependable life of 10 to 20 heats, the exact figure depending on the class of alloy and type of furnace.

In the calamine process for the production of brass the use of a sealed pot was necessary to prevent loss of zinc by volatilisation. Here the sensitivity of the plain clay crucibles to heat shock severely restricted their size, and furnaces holding 40 to 50 crucibles were quite common.

The alchemists were great users of clay crucibles, and are said to have become adept at selecting and blending refractory clays to produce crucibles of low thermal expansion and hence higher-"stunt" resistance. Despite this, crucible failure was frequently claimed as the sole obstacle to the successful transmutation of base metals.

In the early years of the 19th century attempts were made to improve the resistance to heat shock and the thermal conductivity of clay crucibles by including powdered carbon, usually an amorphous type of mineral carbon, in the mixing. Such pots were known as blacklead or Dutch pots, and remained in use until the introduction of the plumbago crucible into England by the Morgan brothers in 1851.

Plumbago.

Plumbago is a naturally occurring crystalline form of carbon chiefly distinguished by its scaly or plate-like formation and its resistance to oxidation or other chemical reaction. The raw material, obtained mainly from Ceylon and Madagascar, is passed through various processes of washing and milling, all designed to accentuate the flakiness by splitting the material along its natural cleavage planes, while retaining a maximum surface area. At the same time it is purified until a final product is obtained of about 90 per cent. carbon, consisting of thin plates approximately 0.05 in. dia. by 0.002 in. thick. In manufacture these flakes are mixed with highly-refractory clays and formed into the crucible shapes by processes which lay and lock the flakes into a strong elastic skeleton capable of considerable distortion without fracture. The plumbago content, which may be as high as 50 per cent., also confers high thermal conductivity.

Coke-Pit Fire.

The earliest and still the most popular type of furnace is the coke-pit fire. The pit fire has the great advantage of initial cheapness with consequent low interest and depreciation charges, while it is extremely flexible. The number of different alloys and specifications that the jobbing founder is expected to supply increases almost daily, and with the pit fire each individual heat may be of a different alloy, or for that matter, metal, varying from lead to steel. Yet another point is that the unskilled, or at most semi-skilled, labour required is cheap and easily obtainable. Maintenance costs are confined to the patching and relining done by the furnaceman in his spare time.

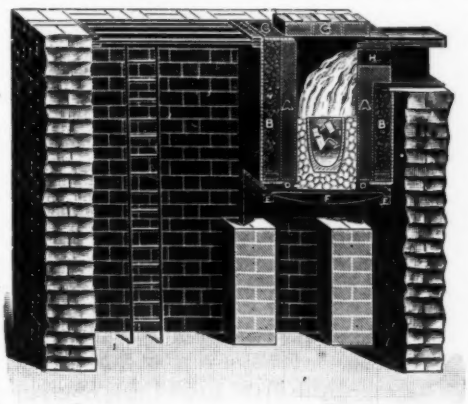


Fig. 1.—Morgan's Natural-Draft Furnace. Sectional View of Single Furnace.

Whilst the non-ferrous metals may be melted in the crudest of furnaces, economical melting can be only obtained in fires in which the melting chamber, the flue outlet and the firebars are correctly proportioned. Fig. 1 shows a standard furnace of correct proportions. It consists of a square sheet steel box built up on a framework of steel angles which project and form legs. The square brick combustion chamber is built up on cast-iron bottom plates. The space between the brickwork and the casing is filled with broken firebrick, or better, insulating brick. The cast-iron firebars (F) rest upon steel bearer bars and are slid along to one side for clinkering out. Between the top of the bars and the bottom of the lining there is a gap (D) of 2 in. The majority of the air enters the furnace through this gap, very little coming through the bars which are closely spaced. This confines the main combustion to the sides of the crucible, the coke under which burns so slowly that there is no necessity to keep lifting the pot to get fresh coke under. The furnace is of sufficient depth to take the whole of the coke required for a heat at one time, since recharging is bad from all points of view. While the pot may be worked quite well upon a bed of coke, as shown, it is better practice to use a plumbago stand a few inches high as this lifts the crucible out of the erosive slag, which is the main cause of crucible wear and which collects upon the bars. This slag is formed by the melting of the ash of the coke and contains a large proportion of metallic oxides, chiefly iron, which react with the clay bond of the crucible, gradually wearing it away. The rapidity of this wear depends on the amount of the ash present and its fluidity.

Types of Coke Available.

Gas Cokes.—Being of course a by-product, gas coke is very variable in character but generally contains a high percentage up to 14 per cent. of ash, while the ash contains as much as 30-35 per cent. of fluxes and has a low melting point forming a very fluid active slag. Crucible life will therefore be low while, owing to the tendency of the coke to break up in the furnace, and its low calorific value, fuel consumption is high. On the other hand gas coke is cheap and usually obtainable locally, saving high freightage rates. Generally speaking its use will be found false economy.

Beehive Coke.—At the other end of the scale is beehive coke, containing about 6 per cent. ash, which in turn contains less than 10 per cent. fluxes. The ash has a higher melting point than is usually obtainable in natural-draft coke furnaces, and there is, therefore, little or no wear on the crucible. The coke is very hard and strong, slow in igniting but capable of giving high temperatures under suitable conditions. Its high price precludes its use for all except special cases such as steel melting.

Patent Oven Coke.—This is a type of coke intermediate in quality between beehive and gas cokes. It is considerably cheaper than beehive while some grades are actually little inferior in quality. Such grades have an approximate analysis as follow:—Total carbon, 92.8 per cent.; ash, 6.4; sulphur, 0.8; and moisture, 0.5 per cent.; the fusing point of ash is 1,500 deg. C. and the calorific value is 13,000 B.T.U., and are available to-day in the London area at a price of 39s. 3d. a ton including carriage, or at 20s. 6d. at the ovens. Progressive makers will supply cokes ready broken to a size suitable for use in furnaces, saving the foundry the labour charge of breaking up and avoiding the loss of coke as dust and breeze which occurs even when a coke-breaking machine is used. For this service some makers make a small charge of a shilling or two, while in one or two cases the broken coke is for some obscure reason cheaper than whole coke.

The actual amount of coke used in a furnace depends on the size of the pot and the draft available. Under average conditions a charge of 160 lb. of gun-metal should require not more than 42 lbs. of coke, a fuel consumption of 26 per cent. Slightly more would be required when starting up with a cold fire, but the fuel consumption should not exceed 28 per cent. for a day of 5 heats. With coke at 39s. 3d. a ton this gives a fuel cost of 11s. per ton of metal melted.

There are on the market to-day special types of crucibles commonly known as "rapid-heating," in which the graphite flakes are arranged to give a higher thermal conductivity. With these the fuel consumption is reduced about 15 per cent. so that we should obtain a figure of 24 per cent. or a melting cost of 9s. 4d. a ton.

The labour cost of running small furnaces is always difficult to estimate, particularly in jobbing foundries. Sometimes the furnacemen are expected to sort out and weigh up their own charges and, in addition, assist in pouring the metal. On the other hand they can generally obtain help from the labourers on the shop floor. One man should be able to look after two fires, getting out five heats of 160 lbs. from each furnace per day, giving an output of 3¾ tons per week. If a furnaceman receives a weekly wage of £3 the labour cost of melting is therefore 16s. a ton. When at all possible the furnace labour should be paid piece work on a tonnage

* A Paper read before the London Branch of the Institute of British Foundrymen, Mr. H. G. Sommerfield presiding.

basis when up to a ton can be obtained per man per shift. "Rapid-heating crucibles" offer a further saving as they reduce the length of a melt by some 20 per cent. enabling an extra heat to be got out per shift. By these means the labour cost on alloys such as gun-metal may be reduced to 12s. a ton. To obtain such figures good organisation is required and there must be no waiting for moulds to be closed, etc.

Crucible Cost.

This figure varies tremendously according to the care used in working, the type of coke and condition of furnace. Crucibles used in coke furnaces are gradually worn away at the lower-half outside by the molten slag from the coke ash and the rapidity of this wear depends on the amount of ash, the fluxing temperature of the ash, the temperature of the fire and whether the pot is allowed to work in the dirtiest part of the fire just over the firebars. Usually this wear will gradually reduce the thickness of the pot material in its chine—the region just above the bottom—to about $\frac{1}{4}$ in. to $\frac{3}{8}$ in. when the internal pressure of the metal will open up a slight crack, through which the metal will slowly seep. It is not usually worth while working a pot to actual failure as the slight saving does not compensate for the risk of losing a valuable charge of metal in the fire. An ordinary crucible of 160 lbs. capacity used under average conditions should give a steady 50 to 60 heats before failing in this way. In recent years crucible materials have been developed which are exceedingly resistant to slag wear. Such crucibles sold under trade names like Super, Excell, Supreme, etc., will give from 50 to 100 per cent. longer life than ordinaries for a slight increase in first cost. "Rapid crucibles" will also tend to give a longer life, as they are exposed to the slag attack for a shorter period each heat. A normal life for a "Rapid Super" crucible of 160 lbs. capacity would be about 100 heats. Taking the crucible price at 32s. 6d., the crucible cost amounts to 4s. 7d. per ton of gun-metal melted. While a life of 100 heats is by no means excessively high, since many people are getting well over this figure, the life can be shortened by many different kinds of abuse, nearly all due to carelessness or lack of knowledge on the part of the furnaceman.

Common Abuses.

"*Stewing*" metal in the furnace while waiting for moulds to be closed. This is a very common practice, exceedingly bad for the metal and for the crucible, as the slag attack is most rapid at the end of the heat when the fire is at its hottest and dirtiest.

Perishing.—Plumbago crucible contains something like 50 per cent. of carbon. Whilst plumbago is the form of carbon the most resistant to oxidation, free access of oxygen to the unprotected crucible will result in the plumbago skeleton burning away, leaving a comparatively soft and weak husk of brownish-grey clay. This process is known as perishing. It should not occur in a coke furnace as the slag from the ash very effectively glazes over the surface of the pot and prevents access of oxygen. In a badly-designed furnace where the top of the crucible is too high relative to the flue, this glazing action is not sufficiently effective to prevent perishing. The perished material is quickly rubbed off by friction of the coke or poker and the top edge of the pot will wear thin and tattered. This same action will occur on the bottom of the pot if it is allowed to rest on the firebars or if the fire is allowed to burn hollow or hang up.

Mechanical damage can be due to many causes and is only too common. There are (1) squeezing out of shape by too heavy tongs; (2) pushing coke through side of pot by tongs; (3) pushing coke through bottom by standing pot down on hard floor; (4) without first seeing bottom is clean, and (4) heavy-handed use of poker and stirrers.

Bumping or Scalping.—The plumbago crucible being clay bonded is both hygroscopic and porous. If exposed to moisture the clay will pick up water and tend to rehydrate, and when the crucible is heated suddenly the water is given off more quickly than the internal pores can pass it, and portions of the material are blown off. This is known as "bumping," and was common in the past, and it was necessary to "anneal" crucibles. Sometimes a weakness is formed which does not show up for many heats, and this is known as a partial "bump." With modern crucibles annealing should be entirely unnecessary provided they are stored in a warm, dry place. As it is impossible to secure absolute protection during transit, it is, however, advisable to take the small precaution of bringing new pots up in a cold fire on the first heat of the morning, taking a little extra time over the heat, say, $1\frac{3}{4}$ hrs. instead of $1\frac{1}{4}$ hrs., and it is advisable to have one or two partially-used pots on hand for use in emergencies.

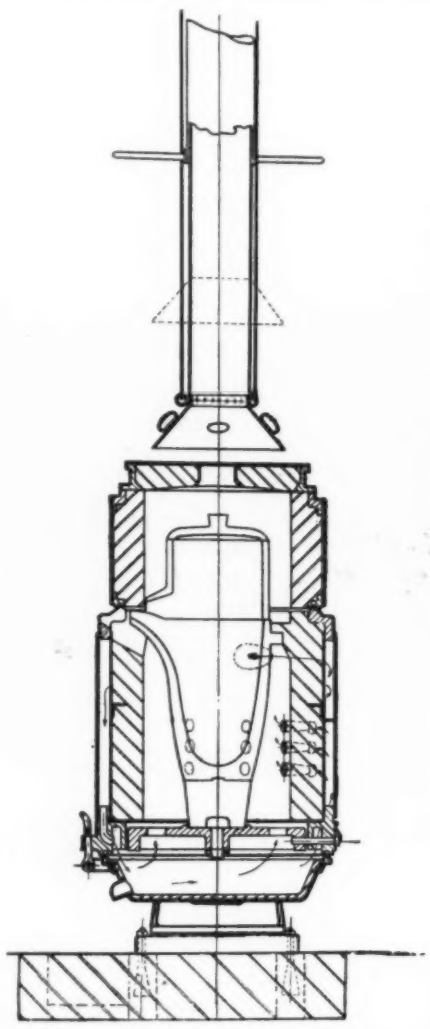


Fig. 2.—Sectional View of Morgan's Patent Tilting Furnace, Type "S."

The surest way of preventing abuse is to pay the furnaceman a bonus based on crucible life. If a crucible costs 40s. and lasts 60 heats the cost per heat is 8d. A substantial bonus of, say, 4d. a heat over 60 to the men will make them exceedingly keen on securing maximum life and preventing the early failures which pull down average results so badly. To be of any use the bonus must be substantial. In the above case, if the men increase pot life to only 70 heats they make 1s. 4d. per pot per week, a sum sufficiently large to cause them to take considerable care. This question of preventing early failure is, of course, very important with expensive crucibles like "Rapid Supers," as it is useless paying extra for wear-resistant material if the furnaceman is going to stick a poker through the pot bottom.

The last expense with the pit fire is the maintenance and replacement of the lining. This may be built in several ways. Fig. 1 shows a one-piece solid firebrick lining, which is simply dropped into the furnace, requiring no skilled bricklaying, while as the change of lining takes only an hour or so there is a minimum loss of production. The one-piece lining is rather expensive, and a cheaper and possibly as good a method is to use eight vertical firebrick slabs recessed into one another at the corners. The usual method is to lay up the lining with ordinary firebrick squares. To make a job of this a skilled bricklayer is required, while the joints are a serious weakness.

Maintenance consists of the occasional patching of the lower part of the lining with ganister, done by the furnaceman in his spare time, and replacement of firebars. A sectional lining for a 160-lbs. furnace costs £3 5s. and should give a life of a least nine months, a cost of 10d. per ton of gun-metal.

Summing up the cost of melting gun-metal is shown as:—Fuel, 9s. 4d.; crucible, 4s. 7d.; labour, 12s.; lining, 10d., a total of 26s. 9d. per ton, exclusive of interest on capital expenditure and depreciation, as in the case of the pit fire, these are negligible.

The natural-draft fire, unless provided with a tall, expensive stack, is always liable to give erratic results, owing to the draft varying with changes in the direction of the wind. For this reason the self-contained forced-draft furnace is becoming popular. A well-designed forced-draft furnace is hotter, and, therefore quicker melting than a natural-draft furnace, and slightly more economical in fuel. The usual tendency is to overblow, which gives an intense bottom heat and comparatively cold top. The crucible may not have sufficient elasticity to meet the stresses induced by such extreme temperature differences, and may fail early by stunt cracking. Apart from this risk of cracking, the overblowing will give excessive localised bottom wear known as "pegtopping." The furnace should be designed to work at a low pressure, not exceeding 2-in. water gauge, the air passages being suitably designed to pass the combustion air at a low velocity.

Tilting Furnaces.

While the pull-out crucible of 60 to 200 lbs. capacity is ideal for a jobbing foundry using many different mixtures, larger units are necessary when large tonnages have to be obtained in a few alloys. On the Continent, large lift-out crucibles are occasionally met with, involving unwieldy pulling and pouring gear, but the obvious solution is a tilting furnace. These are made for coke-firing in capacities from 150 lbs. up to 1,000 lbs., the most popular sizes being 400 and 600 lbs. It is not proposed to say much about coke tilters, as their design has been standard for some years. The furnace (Fig. 2) consists of a steel shell lined with firebricks. The firebars are in three parts, a fixed centre-bar carrying the crucible and two hinged side-bars which are readily removable for clinkering out. For ease in working, the furnace is made in two halves, a body portion and a swinging preheater in which fits the muffle ring. Air for combustion is supplied by a small and preferably motor-driven fan, and enters the combustion space in three ways: (*a*) Through the firebars, (*b*) over the top of the bars and (*c*) through tuyere-holes half-way up the body. The air entering through the tuyere-holes burns with the carbon monoxide produced in the lower part of the fire-bed, giving very efficient combustion.

Good coke is necessary to prevent excessive slag formation in the restricted combustion space, and the coke consumption on gun-metal should not exceed 16 per cent. The greatest saving with the large furnace is in labour, as one man can quite easily get five heats out of a 600-lb. tilter, a total of 3,000 lbs. of gun-metal per 8-hr. shift. Without going into details, the total cost of melting should not exceed 21s. per ton of gun-metal, including interest at 5 per cent. and depreciation at 10 per cent.

The normal type of furnace used for pouring into a ladle or hand-shank is arranged for tilting about a central axis. Where direct pouring into billet moulds is required a special type with the axis at the lip of the crucible is used. As the furnace is out of balance, rather elaborate balancing gear is necessary, which puts up the cost.

In another type of furnace the hot gases of combustion pass down a vertical cast-iron pipe around which the incoming air is circulated. The heat thus recuperated gives a slight increase in combustion-space temperature and a corresponding gain in furnace efficiency.

The furnace bodies may be arranged in various ways to suit special cases. For instance, there are furnaces in which the body is detachable and may be carried about by the foundry crane for direct pouring into moulds, avoiding the transfer of the metal into ladles, with risk of chilling. Apart from this it is convenient, in a big battery of furnaces, to have one or two spare bodies with crucibles ready for use which can be slipped into place of those in which the crucible has failed, giving a minimum loss of production. The size of coke furnaces is limited by the increasing difficulty of securing adequate pokering of the fire bed as the height of the furnace is increased. The maximum size is about 1,000 lbs., while oil furnaces can be made holding up to a ton.

FIG. 3.—MORGAN'S PATENT TILTING FURNACE, TYPE "A." ARRANGEMENT "B" ERECTED ON CONCRETE PIERS ABOVE GROUND LEVEL FOR POURING INTO HAND LADLES.

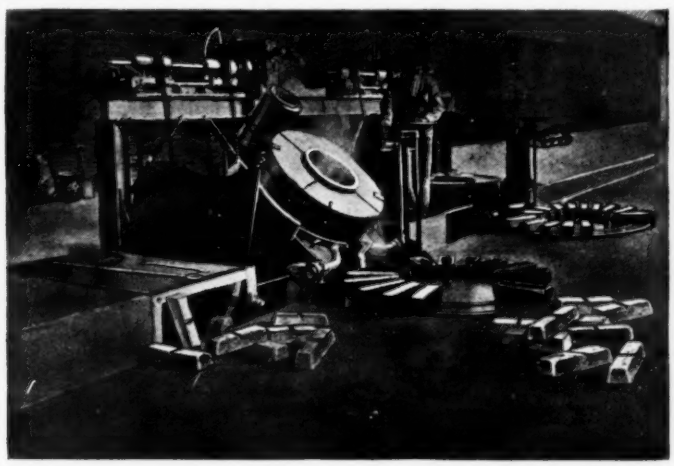


FIG. 4.—MORGAN'S PATENT TILTING FURNACE, TYPE "LA." ARRANGEMENT "B" FITTED WITH ELECTRICALLY-OPERATED TILTING GEAR IN POURING POSITION.

Oil Firing.

The price of fuel oil suitable for use in metallurgical furnaces is about 60s. to 70s. a ton, the exact price depending on the district and the quantity taken. First-class coke can be bought for 39s. 6d. a ton and at first sight it is rather difficult to see how the oil furnace can compete in economy. Oil has a high calorific value of approximately 19,500 B.T.U. per lb. as against 13,000 B.T.U. for coke, but even this does not cover the wide discrepancy of almost 100 per cent. in the price. Actually owing to the high-flame temperature obtainable and other factors such as luminosity of the flame, the oil furnace is so much higher in efficiency that this margin is more than covered. In addition, it allows a very considerable saving in indirect charges, handling, storage and disposal of ashes. Oil furnaces are rapidly replacing coke furnaces throughout England and throughout the world.

The most obvious feature of an oil-fired furnace is the burner, and it is popularly supposed that the burner is the all important part; actually it is of much less importance than the correct design of combustion chamber and it is on this point that most home-made furnaces prove unsatisfactory. The burner is merely a device for pulverising the oil into as fine a mist as possible and delivering it mixed with air in a jet of correct shape and size. Almost any of the burners on the market will atomise efficiently, but very few of them will give a jet of the correct shape for the narrow combustion space of a crucible furnace. The atomisation can be achieved in several ways:—(1) with high-pressure air; (2) with low-pressure air; (3) with steam, and (4) with pressure oil.

Air Supply.

Of these the pressure-oil systems are generally too complicated for a foundry, while steam is ruled out owing to its damping effect on flame temperature and the reactions that take place between superheated-water vapour and molten metal. High-pressure air, generally anything from 20 lbs. to the sq. in. to 100 lbs. to the sq. in., is obtained from a positive air compressor, while low-pressure systems, up to 12 oz. to the sq. in., derive their air from fans. The high-pressure system is probably slightly the more efficient but compressed-air plant is expensive in first cost and maintenance, while the burner is small with tortuous air passages liable to become choked in the rough conditions usual in foundries. The adoption of the low-pressure system involves the laying down of a fan costing probably £30 but is generally worth while. A low-pressure burner designed to work at 1½ in. of mercury column, equivalent to 20 in. of water or 12 ozs. to the sq. in. supplied by a high-speed fan, is satisfactory, as the air passages are large, the main one being 3½ in. dia. so that there is very little chance of blockage.

Oil is supplied by gravity from a service tank 10 to 15 ft. above the burner and its rate of flow is controlled by a needle valve. The air supply is split up inside the burner into two streams, one of which goes through an inner annulus and is directed on to the oil stream, which it breaks up and atomises. The main-air passes through a separate passage and issues in the form of an envelope surrounding the air-oil mixture. To suit oils of differing viscosities, the size of the atomising aperture can be altered while the volume of main air can be controlled by a shutter at the burner nose. This is very important as when the furnace is not required to run its maximum speed of melting, the oil may be cut down and with it the air supply without lowering the standard of atomisation. Such a burner when once set and adjusted to give the best results is almost entirely foolproof and can be left to run under extremely bad conditions and for extended periods without further attention.

The atomised oil stream is directed tangentially into the combustion space through a long extension called an injector box and spreads out against the furnace lining around which it wraps itself in its helical passage through the combustion space, centrifugal force causing it to scrub the walls of the lining. The mouth of the extension is shaped to act as an injector, and, in fact, only half of the air burned in the furnace comes from the fan, the other half being induced from the atmosphere. It is important that the oil should be well alight before it reaches the crucible, and early combustion is assisted by a baffle rod placed across the mouth of the injector nozzle. This causes eddies and turbulence in the stream, and also causes a little of the oil to be thrown on to the walls where it flames, promoting early combustion of the main stream. By the time the mixture reaches the end of the injector passage the flame is well alight and most of the oil has volatilised. An unsuitable burner and inaccurately-centred jet will cause oil to be thrown on to the walls of the furnace or on to the crucible and will inevitably result in the formation of much troublesome growth of carbon. Carbon deposits may also be due to unsuitable fuel oil containing either much free carbon or else easily-cracked hydrocarbons. With the thin present-day fuel oils there is no reason for any serious carbon deposit, providing the burner is suitable and is accurately centred.

The flame swirls several times round the crucible and muffle ring before emerging from the furnace, preferably through a narrow slot round the muffle ring. This arrangement is rather better than exhausting the waste gases through a horizontal flue at the back of the furnace, as the latter practice is apt to give a cold top to the furnace.

The longer the flame path the lower will be the temperature of the flame as it leaves the

combustion space, and hence the higher the efficiency of the furnace, and sometimes attempts are made to lengthen the flame path and to ensure complete combustion by fitting firebrick baffles in the flame path. These, however, are almost entirely useless, as they either spall off or are cut away by metal spilt over the side of the crucible, and it is far better to rely on the correct shape and width of the combustion space. Connection of the waste-product outlet to a flue is to be depreciated, as the shape, size and colour of the issuing flame provide valuable guides to the correct regulation of the oil and air mixture.

In a normally-ventilated foundry the free escape of the products of combustion into the atmosphere will have no ill-effects, while in poorly-ventilated foundries a simple collecting hood is sufficient. Sometimes exception is taken to the apparent loss of heat in the flame, and attempts are made to recuperate part of this by warming up the air supply. While this will give very good results in large installations, it is not practicable with small furnaces, as the recuperator tubes—if of metal—quickly burn and scale away, and if of silicon carbide or other refractory material, are almost impossible to keep airtight. Moreover, the increase of volume which attends the heating up of the air is very embarrassing as it involves enlarging the size of the burner with consequent poor atomisation when using cold air on starting up. It is therefore much better to use the heat in some form of core stove or heating oven. In any case the loss is more apparent than real.

Oil Consumption.

The actual amount of oil required to melt a given quantity of metal depends to some extent on the size of the furnace. Gun-metal can be melted in a furnace of 15 cwts. capacity with a fuel consumption of 9 per cent. while in a 150-lb. furnace it will take 16 per cent. The fuel cost on gun-metal in the large furnace, with oil at 60s., is 5s. 5d. per ton. This figure is amazingly low—lower in fact than that claimed for open-flame reverberatory furnaces in which the metal is in direct contact with the flame. This would at first sight seem impossible, but it is due to the fact that the metal contained in a tall, narrow crucible is constantly stirred by convection currents, giving a high degree of heat transfer. In the open-flame furnace once the metal has melted it is heated from the top, and through a blanket of slag; there is no convection, and the heat is passed to the bottom of the bath by conduction only. As there is a constant drain of heat from the refractory bottom of the hearth the efficiency is very low.

Since oil fuel contains a negligible amount of ash there is no wear on the outside of the crucible as there is in a coke furnace, but the free oxygen in the flame and the superheated water vapour derived from the combustion of the hydrogen in the fuel tend to react with the plumbago or carbon content of the crucible, and unless it were protected it would rapidly burn away, leaving a weak clay skeleton. This action is prevented by glazing the crucible, that is, by providing it with a thick hide of vitreous material, which is liquid or at least gummy at furnace temperature. This glaze is exceedingly effective even at aluminium-melting temperatures, and, provided it is not damaged by careless handling during the setting of the crucible or by excessive zeal in breaking away carbon, the crucible can be used for long periods without any signs of perishing.

The usual cause of failure of such crucibles is thinning at the top, a process which may be due to any one of several causes. The erosive action of flux is intensified in the slightly oxidising atmosphere of the oil furnace and the use of excessively large quantities of strongly-reacting fluxes will cause rapid top wear, particularly if used so carelessly so that some is allowed to go over the side of the crucible. Brasses and bronzes, particularly with a high copper content, may form a copper-oxide slag in the absence of charcoal or a protective coating sufficiently active to give excessive top wear. Under normal circumstances of quick melting and rapid emptying, the amount of copper oxide should not be sufficient to cause material damage, but if the oil flame is allowed to play directly on the metal or the metal is held at a high temperature for an extended period trouble is almost certain to occur. This cutting action is particularly severe when metal is allowed to spill over the side of the crucible. As it runs down the walls it oxidies, and the resultant copper oxide cuts channels in the crucible material. The top edge of the crucible is also liable to be damaged during charging heavy scrap or during stirring and skimming, so that in crucibles specially made for oil furnaces the top part is always thickened up to allow for this wear. With normal handling a crucible used in a well-designed oil-fired tilting furnace, melting brasses and bronzes should give a life of 80 to 100 heats. As the cost of the crucible is roughly proportional to its size, the crucible cost per ton of metal is sensibly constant over a range of sizes and for a life of 80 heats will be 4s. 2d. a ton.

Labour Cost.

With oil-firing the fuel is brought to the furnace by gravity, and, once lit, requires no pokering or further attention. The furnaceman's job is only semi-skilled and consists of charging and pouring the melt and giving an occasional moment to the oil control. The correct proportion of oil and air can be readily gauged by an examination of the flame coming from the flue outlet. The flame should be about 6 in. high and a full white colour. A heavy, reddish, smoky flame indicates too much oil, while a transparent, feathery flame shows an excess of air. This pilot flame can be seen from a considerable distance, and there is no need for the furnaceman to stay by the furnace. In the case of a one-furnace installation, the furnaceman can be usefully employed during a melt on general labouring on the floor, while in larger installations one man can look after two or more units. The actual labour cost, of course, depends on the exact duties he is expected to perform. One can take as an average figure that one man can look after two furnaces each of 600 lbs. capacity. If he is paid £3 per week this will give a labour charge of 4s. 2d. a ton. It should be noticed that the furnace has not to be cleaned out at the end of the day's work nor the ashes carted away, so that when the last heat is poured his day's work is over.

The lining of an oil furnace is entirely unaffected by the oil-fuel, and its life will be determined by the amount of metal spilt over the side of the crucible and damage done in cleaning away carbon. It is fairly safe to assume that in a furnace used on bronze, a lining will give six months' service, giving as a rough figure a cost of 10d. a ton of metal. This figure is an arbitrary one, but it should be borne in mind that the weekly patching-up usual in coke furnaces is not necessary. The furnaces themselves are simple and cheap, and interest and depreciation will work out at 1s. a ton. The total cost of melting under the above headings is therefore 16s. a ton of gun-metal, a figure which compares very favourably with any other system of melting.

Oil-firing can be applied to pit furnaces, but such small units are not so economical as tilters, yet they have several advantages over coke pit-fires. Like all oil furnaces, they are particularly suitable for melting valuable alloys, as the metal spilt into the combustion space is not contaminated by the fuel, but may be run out through the drain-hole and saved.

With solid fuels, the maximum temperature obtainable without recuperation is limited, while high-temperature furnaces are rarely economical. Owing to the high calorific value of oil-fuel, the flame temperature in the furnace is high, and 1,500 to 1,600 deg. C. can be obtained without any recuperation. This makes the oil furnace particularly suitable for melting the more refractory metals such as nickel, iron and steel. As an example, 300 lbs. of pure nickel-shot may be melted in 2 hrs. with a fuel consumption of 50 per cent. with definitely no contamination of the metal. While melting costs have been given for gun-metal only, practically all metals, from lead to platinum, can be melted in crucibles of suitable material.

Melting Aluminium.

Aluminium is rather a tricky metal to melt, as, despite its low melting point and low specific gravity, it has high specific- and latent-heats and, to secure reasonable melting times, heat has to be supplied at a considerable rate. On the other hand, it is fatal to overheat the metal, so that the heat-flow must be capable of easy regulation. The coke furnace is rather at a disadvantage owing to the reservoir of heat in the fire bed around the crucible. In the oil furnace the fuel may be turned off at a given pyrometric reading and the metal will make only 10 to 20 deg. C., the slight rise in temperature being due to the heat in the lining. There is generally enough of this heat in the lining to keep the metal temperature sensibly constant for 10 to 15 min. Aluminium was formerly melted in gas-fired iron pan furnaces, but, owing to the high cost of town's gas and the risk of iron contamination, these have been almost entirely replaced by oil-fired plumbago-crucible furnaces. There is a considerable demand for large furnaces of 5 cwts. aluminium capacity, and an installation of two such furnaces, arranged to pour into a common ladle, gives very low running costs. For instance, one plant achieves the following:—

(*a*) *Fuel consumption* is 11 per cent., so that with oil at 60s. per ton the fuel cost is 6s. 7d. a ton.

(*b*) *Labour* involves one man to each furnace, getting out eight heats a day or 11 tons a week, which gives a labour cost of 5s. 6d. a ton.

(*c*) *Crucible costs.*—Two crucibles at 47s. 6d. and lasting 100 heats will cost 9s. 10d.

(*d*) *Lining, interest and depreciation*, say, 2s. 2d. per ton.

(*e*) *Total cost of melting* is therefore 24s. per ton of aluminium melted.

The old basin-type of furnace was very convenient for baling out with hand ladles and has been retained by the die-casting trade. While melting costs are slightly higher than with the more efficient tilters, the furnaces are generally used for storage and a charge of 300 lbs. aluminium can be kept at working temperature with an oil consumption of 3s. 4d. a gallon, roughly 2¼d. per hour. The life of the basin would be about eight weeks. In the past few years much research has been directed into the properties of cast iron, and several new types have been developed for special applications. While they may be melted cheaply in the cupola, it is extremely difficult to ensure that the analysis falls within the rather narrow specifications. Such cast irons may be melted more conveniently in tilting furnaces of about 400 lbs. capacity. The melting cost is comparatively high, about 40s. a ton, but the analysis may be controlled within extremely narrow limits.

Gas Furnaces.

The high price of town's gas precludes its use for furnaces other than for special uses such as in laboratories where cleanliness and ease of control are essential. On the other hand, producer gas is very cheap, while as a fuel it possesses many of the good qualities of oil. Unfortunately, it has a low flame temperature, and it is necessary to preheat the air supply to obtain good results. This means adding a recuperator with its attendant troubles and makes the furnace bulky and expensive. Producer gas has not the popularity it deserves.

Electric Furnaces.

There are three types of electric furnace: arc, induction and resistance. The arc furnace is, of course, well established for steel melting, but the high localised temperature of the arc makes it unsuitable for non-ferrous metals. Induction furnaces of both high- and low-frequency types are very efficient, but their range of application is so narrow and they have been so freely discussed that it is not necessary to deal with them here. Resistance furnaces are again divided into two types, direct and indirect. In the latter the metal contained in the plumbago crucible or firebrick hearth is heated by radiation from nickel-chromium resistor elements. Power consumption is high owing to the poor efficiency of heat transmission, but their main trouble is short life of the heating element, as one splash of metal on to the resistor may cause its failure.

The direct-resistance furnace, in which the crucible itself forms the resistance, is a greater commercial success. The furnace itself is simple, consisting of a steel shell in which the crucible is supported by several inches of heat-insulating material, while the crucible has terminal extensions at the top and bottom, on to which connection is made. The resistance of the crucible is very low, about 0.2 ohm, and a low safe voltage of about 16 volts is used, obtained from a transformer with several tappings which allow the voltage to be adjusted to follow the slight variations in resistance that occur in use. While several of these units are in use in England, most of them have been installed in countries like Sweden where electric power is cheap and plentiful.

Metal Losses.

Despite the present low price of the metals, melting losses constitute a very real expense, while the question is a very vexed one, as losses are difficult to measure and there is no definite agreement as to what should be included. The furnace builder defines the metal loss as the difference between the weight of metal charged into the crucible and the weight poured, assuming negligible spillage, as metal lost by careless charging and pouring is not a fair charge against the furnace.

Test runs on a 10-cwt. oil-fired tilting furnace have shown the following results:—

Yellow brass	...	¾ to 1 per cent.
Red brass ...	...	¾ per cent.
Gun-metal ...	...	½ per cent.
Copper ...	...	¼ to ½ per cent.
Aluminium...	...	½ to ¾ per cent.

These losses are exceedingly low due to the complete protection afforded the metal by the crucible, muffle ring and cover. Careless working and unsuitable furnaces, particularly of the open-flame type, may lift the metal loss with brass and gun-metal as high as 4 per cent. Although this loss is chiefly reckoned as zinc and at £13 per ton of zinc = 10s. 5d. per ton of metal melted, part of it is undoubtedly loss of copper from oxidation and reaction with the firebrick hearth. If we assume that a 4 per cent. loss is made up of 2 per cent. zinc and 2 per cent. copper at £30 per ton, then the cost of this loss amounts to no less than 17s. 3d. per ton metal melted. A sum larger than the total cost of melting including crucible, labour and fuel in the oil-fired crucible furnace.

Furnace Atmosphere.

In the past few years considerable study has been given to the effect of furnace atmosphere on the charge, and it has been shown that absorption of the furnace gases is responsible for many casting defects. The foundry foreman of the old school was always frightened of the metal getting burnt or oxidised, while the present-day metallurgist seems to prefer a slightly oxidising atmosphere rather than a reducing one. With the coke furnace conditions are almost always reducing, the products of combustion containing a substantial percentage of carbon-monoxide. The CO content varies considerably during the heat, being practically nil at the beginning rising to about 5 per cent. after a quarter or half an hour, when the fire bed is well established with comparatively cold coke above and falling to the minimum again at the end of the heat when the fire bed is reduced to a few inches. Bad pokering and shallow furnaces may cause free oxygen to be present.

The forced-draft furnace will give a higher CO content than natural draft and overblowing will send it up as high as 7 to 8 per cent. Of the sulphur content in the coke usually half remains fixed in the ash and half appears in the flue gas as sulphur dioxide, usually showing about 1 per cent. Hydrogen can come only from coke that has been allowed to become wet. The use of wet coke is a pernicious practice, bad for metal quality, crucible life and fuel economy. Under certain circumstances, such as the sudden charging of wet coke into a hot furnace, the hydrogen content of the flue gas may rise as high as 1½ per cent.

The oil furnace affords an entirely different atmosphere, since to obtain economic and smoke free combustion it is necessary to introduce a certain amount of excess air. With good atomisation and furnace design the amount of excess is small and not more than 1 to 2 per cent. of free oxygen should be present in the flue gas. It has been shown recently that one of the main causes of pin holing in aluminium and gasiness in copper is absorption of hydrogen by the metal following reaction with superheated water vapour. Unfortunately, oil being a mixture of hydrocarbons must necessarily give a wet atmosphere, and from a standard oil containing approximately 12.0 per cent. of hydrogen, 1 lb. of steam is produced for 15 lbs. of flue gas. To avoid hydrogen absorption therefore it is important to protect the metal from direct contact with the furnace gases and in the latest design the metal is contained in what is practically a sealed vessel. This protection also serves to keep out the sulphur, which is very necessary as fuel oils contain a variable, but usually fairly large, sulphur content, the whole of which is converted into sulphur dioxide.

At several meetings of the Institution of British Foundrymen it has been said that as the plumbago crucible is porous it affords no resistance to the flow of gases through it and into the metal. This statement is partially true inasmuch as the crucible material itself is quite porous, but under working conditions the crucible is covered by a layer of thick, gummy slag which seals the surface pores and very effectively prevents the passage of gases. In the coke furnace this layer is self-forming, while for oil furnaces the maker supplies a special crucible which is coated with a glaze during manufacture. The main purpose of this glaze is to hinder perishing or oxidation of the carbon content of the pot, and it is exceedingly efficient. A piece of crucible (exhibited) had been kept under severely-oxidising conditions for some months, and shows definitely no sign of oxygen penetration on the glazed side, while the unprotected part is burnt out to half its depth.

Flux Attack.

Practically all the known salts have been proposed or used at one time or another as fluxes in metal melting, and the study of the reactions of the metallic oxides is a fascinating one. As the subject was so ably covered by Mr. Bailey earlier in the session the author will confine his remarks to the action of the fluxes on the crucible. Any flux that is of any use at all for absorbing metallic oxides must necessarily attack the clay bond of the crucible, as clay is a compound of alumina and silica. The best practice is to take a comparatively inert flux, use as little as possible, and to add it at the end of the heat when the metal is at pouring temperature, throwing it on to the surface and stirring in vigorously, then pouring the metal straight away. It is very bad to add the flux with the cold charge at the beginning of the heat, since it melts easily and forms an exceedingly active superheated pool in the bottom of the pot which rises with the metal, cutting and rotting away the entire inner surface of the crucible.

Boro-calcite is probably the best all-round flux. It is about the same price as borax, but as it contains only a small amount of water of crystallisation as compared with the large percentage in borax, it is really considerably cheaper. When thrown on to the metal it quickly spreads over the surface, forming a thin protective layer which will readily trap and dissolve oxides and dirt brought to the surface by stirring. The use of powdered charcoal is almost standard practice and is bound to have a beneficial result, and, of course, has no effect whatsoever on the pot.

The author has attempted to outline some of the ways in which the plumbago crucible is used and abused. To meet the different conditions met with the maker has to supply crucibles of different types, some, for instance, especially resistant to flux attack, others very elastic to suit forced-draft furnaces. Best results can only be secured by close co-operation between the user and the maker, and it is a great help if the traveller be allowed access to the foundry and not stopped at the buyer's office, for even if he cannot offer any personal help, he is trained in observing and reporting on conditions of use, so that the right type of crucible can be supplied.

London Foundrymen visit Welwyn Garden City.

London Branch. — About thirty members of the London Branch paid a visit to the works of the Norton Grinding Wheel Company, Limited, Welwyn Garden City, and the Welwyn Foundry, Limited. They were received by Mr. Frank Emery, managing director of the Norton Grinding Wheel Company, and Mr. L. Crump, secretary and manager of the Welwyn Foundry, at the Cherry Tree Restaurant, where luncheon was served. Afterwards the party visited the Welwyn Foundry and witnessed the manufacture of cast-iron soil pipes on quantity-production lines.

The Norton Company's works, which were built only last year, proved to be a model of modern factory lay-out. Every department is airy and well lighted and, although fine powders are used in the manufacture of grinding wheels, dust was conspicuous by its absence. Every type of grinding wheel from 2-ft. down to ½-in. dia. and from 7 in. thick down to the thinness of a wafer was seen in course of manufacture. Elaborate and well-laid-out testing apparatus, and a careful system of inspection, ensures that each wheel leaves the works as nearly perfect as possible.

Tea was provided by the hosts, after which a cordial vote of thanks by MR. H. G. SOMMERFIELD, responded to by MR. F. EMERY, brought an interesting and enjoyable visit to a close.

Economic Conditions in Belgium in 1931.—The Department of Overseas Trade has published under the above title a report by MR. N. S. REYNTIENS (Commercial Secretary to the British Embassy in Brussels), with an Annex on the Grand Duchy of Luxemburg. Copies (price 3s. 6d. net) may be obtained direct from the Stationery Office, Adastral House, Kingsway, London, W.C.2, or through any bookseller.

Professor Wheeler and the Salerni Process.—In view of reports which have appeared in the Press, Professor Wheeler desires that it should be clearly stated that he is in no way concerned with the commercial exploitation of the Salerni low-temperature carbonisation process. He has given advice and assistance in the technical development of this process such as, in his position as Professor of Fuel Technology, he gives in any other coal industry problem; but he is not in any way concerned commercially in this particular process.

Applying Foundry Technique to Spun Pipe Manufacture.

IMPORTANCE OF ATTENTION TO DETAIL.

When Mr. J. B. Allan replied to the discussion on his Paper which was printed in our last issue, he constantly emphasised that it was attention to detail and the application of ordinary foundry technique which had successfully solved the various problems which had arisen in the course of the *mise en route* of Staveley's new sand-spun pipe plant.

The discussion was opened by Mr. J. R. Hyde, who said they must all have been impressed by the thoroughness with which all the details had been studied. Mr. Allan had told them something of how the plant had been altered and improved. The remarkable thing was that the plant, in its original design, was able to function. He himself had never seen quite the same method of charging the cupola which Mr. Allan had described. He would like to know whether any difficulty was experienced in regard to regular charging by shooting the material in at an angle or whether they got any excessive wear on the lining which received the benefit of the angular charging. In a recent lecture in cupola practice it was urged that the charge should be carried in bodily with a circular skip and with a drop bottom, avoiding in this way wear and irregular charging. He would like to know the internal diameter of the cupola, for he imagined that this would have something to do with the usefulness of the device for smaller plants. He hardly thought that many of those present would be concerned with outputs of 15 tons an hour. They were interested in smaller types of plant.

Mr. Allan said that no trouble was experienced in regard to the regularity of the charges. As a matter of fact the regularity of the metal from those particular cupolas was much better than was the case where a different method was used in another part of the works. There were 10 other cupolas. In regard to the wear on the lining the internal diameter was 54 in. inside the lining. He would not call the wear excessive at all. They had at the works another type of cupola charged in the way that had been mentioned with a skip and a drop bottom and the wear in that case was greater. As to whether the method he had described was completely applicable to smaller types of cupolas he should think it was for a considerable distance down their range, but they would certainly arrive at a point where it would not be—probably at the point when they got to nearly a hand-charged position.

Mr. Hyde: Would you consider 3 ft. too small for this method?

Mr. Allan: I do not think we would apply it to a cupola of 3 ft. dia., having regard to the composition of the metal.

Continuing, Mr. Allan said that the irons they were using were really the same irons as they used at the pit shops but they sorted them out very carefully. Actually they had 12 different grades and silicon content and the charges were selected from these very carefully. They had no difficulty in getting the particular composition they wanted for the pipes. This had been arrived at as the result of experience.

Body Pattern Material.

Mr. T. C. Firth inquired as to what Mr. Allan considered to be the most suitable material for the body patterns, especially the smaller sizes, and whether there was any arrangement for braking promptly in a perpendicular direction so that there was no twist on it at all.

Mr. Allan said he knew that Mr. Firth had what one might term an ulterior motive for asking the questions, for they had something to do with a pattern in which he was interested. He did not know which was the most suitable material for a body pattern of small diameter. They were trying to find out that themselves. They had used cast irons and they had used mild and hard steel, and the results so far were very indefinite. They had had good results from certain cast irons and good results from certain mild steel. They had had bad results from certain cast iron. They were, in fact, still uncertain on the point. They were quite satisfied in regard to the bigger ones. With any pattern 6 in. dia. and above they really had no trouble. In regard to withdrawal, he thought it would be difficult to improve upon their method, whereby the withdrawal tackle was suspended immediately above the pattern. Care was taken to line it up and there was a direct pull. He did not think there was any risk whatever of twisting in the withdrawal. Any trouble of that sort, he thought, took place in the pattern itself, which probably contained internal stresses, these being released to some extent by the jolting and distortion thereby being produced. Or, alternatively it might be caused by the jolting itself, but he rather doubted whether this was likely.

Mr. M. Brown expressed appreciation of Mr. Allan's Paper and upon the study he had evidently devoted to it. He remarked that there had been no covering up of details. He understood the lecturer to say that the cupola charging tables were loaded direct from the magnet. It seemed to him that there might be a difficulty in loading them accurately unless the charge was weighed before the magnet was allowed to pick it up. This did not seem practical, as the tables were mounted on weighing machines.

Mr. W. T. Kitching asked how Mr. Allan got his coke up to the platform. He realised that with a magnet they could eliminate manpower, but he could not understand how they dealt with coke.

Mr. Allan replied that the coke was loaded into rectangular skips with drop bottoms. The skips were lifted up by the magnet cranes and practically deposited on the tilting table. The bottom was released and the coke slid out. He would not say that it was absolutely accurate every time, but it was not far off.

Mr. A. E. Roebuck said he had been very interested by Mr. Allan's reference to the inspection of the sand-spun pipes. They would observe that he said that the pipes were inspected and tested whether the customer's inspector was there or not, and as there was rather a distinguished number of the inspection fraternity present that evening he would like to remind the lecturer on behalf of many firms that they in Sheffield did the same thing. He appreciated that Mr. Allan had not attempted to discuss all the points, and he (Mr. Roebuck) was wondering if he had any trouble with the cast-iron flasks. He wondered if any trouble was experienced with distortion. Presumably the heating was not excessive and did not cause trouble. He would like to know if the steel hoops that had been mentioned were shrunk or pressed on cast-iron flasks. If so, did they manage to keep them tight? Could Mr. Allan give them one or two comparisons with the well-known centrifugal casting plant, the de Lavaud process? Perhaps he would give them the tonnage produced in a certain time or the number of pipes produced.

Mr. Allan said his firm were rather pleased with their inspection department. It had nothing whatever to do with the production side. There was a chief inspector with his own staff and he was responsible to nobody but himself. They were quite satisfied that when a casting passed their inspection department it was definitely sound and good in every possible respect, and that this would be the case whether it was examined by a dozen other inspectors or not. They were prepared to give a certificate that every pipe they made was properly inspected, gauged and tested and they stood by that. They were quite clear on that point. It was a stringent rule. The flasks were of cast iron. They were machined inside and out. The tyres were of nickel-chrome steel and were shrunk on. They had lost one flask since the plant started and that was due to an accident. He thought he might say that they really had no trouble with the flasks themselves. The question of gauging was a very important one. Gauging to fine limits was absolutely essential in the plant. They were used to talking in thousandths. It had obviously taken some time to get a considerable number of people who had not been used to it in the way of it, but it had been done quite satisfactorily. This was proved fairly well by the fact that they had never had a stop. They had managed to go through quite satisfactorily from the start right up to the present time, and they had never had a forced stop except, he thought, on two occasions, when they had a breakdown. One was on a conveyor, he believed. He did not think they had scrapped a flask yet, apart from the one lost by accident. As soon as the two rings got out of gauge they were sent straight away for reconditioning. That generally meant a new flange. There had been very little trouble with the flasks. Indeed, they had been very satisfactory. In regard to the speed of the flasks, it should be explained, that there were four sizes of flasks, and they were primarily designed for 6-, 8-, 10- and 12-in. pipes. They could have 4-in. pipes in 6-in. flasks, and 5-in. pipes in 6-in. flasks, 7-in. pipes in 8-in. flasks, and so on, the difference being according to the thickness of the sand. The speed in the case of the 4-in.. was about 1,300 r.p.m., and at 12-in. about 550 r.p.m. The estimated output of the normal sizes was 50 an hour. They had certainly gone for four hours consecutively at 60 an hour. Normally the speed was 50 an hour—that was for the whole plant.

In regard to the competitive plant that had been mentioned, he had seen the plant, having spent a day there. He could not say that he was very familiar with speeds and so on, but the speeds of the plant with which he was concerned were certainly higher. In the de Lavaud process, as they were aware, the metal solidified almost immediately. In the case of his plant the metal was distributed when definitely quite fluid. In fact, it depended upon fluidity for distribution. The speeds of his plant were higher than those of the plant that had been mentioned.

Mr. J. Roxburgh said he was not quite clear about the running of the pipes, and inquired if the metal was simply projected in from the end and the centrifugal force relied upon to carry the metal forward to the end of the mould, or whether it was projected so far into the mould. Also he would like to know how much sand was run round the pattern. He understood the lecturer to say that a synthetic sand was used.

Mr. Allan said the metal was merely poured in by tilting the small tilting-ladle containing a definite weight of metal. The metal was poured into a runner which transferred it to the mould. It was only a matter of a few seconds before it was distributed all over. The sand was a synthetic sand, and the thickness of it was nominally 2 in. for a normal-sized pipe in its proper flask. Obviously, in a 4-in. pipe and a 6-in. flask it was thicker.

Mr. Steele said he was interested in the question of the depth of the box, which he under-

(*Concluded on page* 332.)

Austenitic Cast Irons.

The development, properties and applications of the austenitic cast irons have recently been discussed in the FOUNDRY TRADE JOURNAL in the second part of the report of the Paper by Dr. A. B. Everest on "Cast Irons with Higher Nickel Additions."* This class of alloy is the subject of the latest publication of The Bureau of Information on Nickel (publication B.9—"Austenitic Cast Irons") which contains much additional information of interest to engineers and foundrymen alike.

The booklet contains a number of pictures which are suggestive of a wide field of application, and show examples of a variety of castings in which the austenitic cast iron has proved of interest from one point of view or another. The value of the publication is further enhanced by exhaustive tables showing the properties of these irons.

FIG. 1.—TEST-PIECES OF AUSTENITIC AND ORDINARY CAST IRON AFTER IMMERSION IN 5 PER CENT. SULPHURIC ACID FOR 100 HRS.

The outstanding properties of the austenitic cast irons are enumerated as follow:—(*a*) A marked degree of corrosion-resistance; (*b*) a superior resistance to the effects of heat; (*c*) non-magnetic, with suitable compositions; (*d*) a high electrical resistance coupled with a low-temperature coefficient of resistance, and (*e*) a high coefficient of thermal expansion.

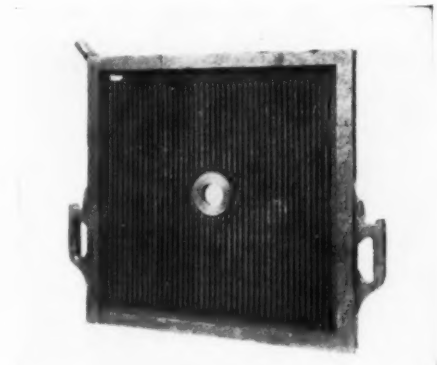


FIG. 2.—AUSTENITIC CAST-IRON FILTER PLATE, AS USED FOR FILTRATION OF CAUSTIC LIQUORS IN SOAP WORKS.

The mechanical properties of the irons are given as being very similar to those of ordinary cast iron. Photomicrographs are also shown illustrating typical structures of corrosion and non-magnetic cast irons, and there is also one photograph showing an austenitic iron containing traces of martensite as a result of insufficient alloys.

Under the heading of composition the use of nickel in obtaining the austenitic structure is described, and it is then shown that, within limits, part of the nickel may be replaced by other elements such as copper and manganese; chromium is mentioned as a hardener.

The corrosion-resistance of the austenitic cast iron is dealt with in detail and Table I gives an idea of the wide range of industrial fluids in contact with which the austenitic cast irons are of interest. This table is supplementary to two tables given in Dr Everest's Paper and, in many respects, gives satisfactory confirmation of the results obtained from other sources. Applications of the austenitic iron in the chemical industries are shown in the accompanying illustration, which suggest the use of the special metal for such parts as pumps, filter plates, valves and a hundred and one other castings which are in use in chemical plant.

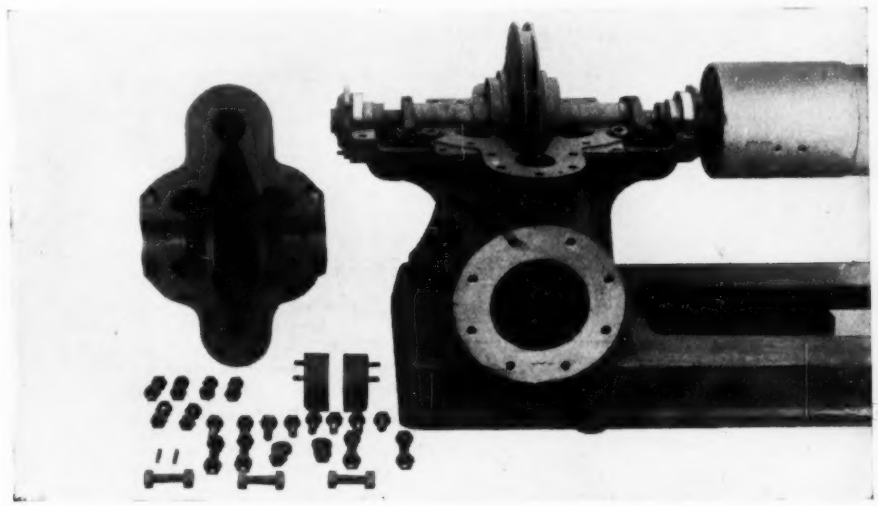


FIG. 3.—CENTRIFUGAL PUMP FOR HANDLING CORROSIVE AND EROSIVE LIQUORS. THE CASING AND IMPELLER ARE MADE IN AUSTENITIC CAST IRON.

TABLE I.—*Comparative Rates of Corrosion.*

Reagent.	Austenitic cast iron.	Ordinary cast iron.	Brass.	Bronze.
5 per cent. Sulphuric acid cold	1	475	1.12	1.08
10 per cent. Sulphuric acid at 100 deg. C. ..	1	195	0.15	0.15
78 per cent. Sulphuric acid at 100 deg. C. ..	1	1.95	—	0.08
5 per cent. Hydrochloric acid ..	1	185	13.0	24.0
25 per cent. Acetic acid ..	1	400	2.75	2.22
Salt spray ..	1	2.9	0.27	0.08
Sea water ..	1	5.0	0.5	2.15

TABLE II.—*Weight Loss of Austenitic and Ordinary Cast Irons under Erosive Conditions. Mather & Platt, Ltd.*

Mixture.	No. 7 Alloy.	Cast iron.
Sand and water 40/50 ..	145	320
Coal dust and water 50/50	18	84
Clinker and water 50/50 ..	144	320

An interesting feature shown in Table III is the similarity in chemical resistance which exists between the austenitic cast irons and such non-ferrous alloys as brass and bronze. The austenitic irons can be manufactured at a cost which competes with that of the non-ferrous

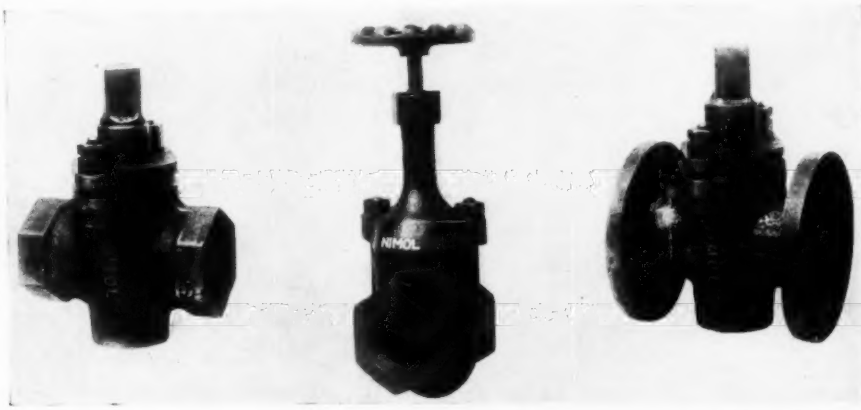


FIG. 4.—VALVES IN AUSTENITIC CAST IRON AS USED IN CHEMICAL PLANT AND PETROLEUM REFINING, ETC.

* FOUNDRY TRADE JOURNAL, April 7, 1932, page 217.

TABLE III.

CORROSION TEST RESULTS ON AUSTENITIC CAST IRON ("No. 7 Alloy") COMPARED WITH PHOSPHOR BRONZE AND ORDINARY CAST IRON.*

Figures represent the loss in milligrammes per square decimetre per day under static conditions at 20°C.

(Corrosive Medium.)	"No. 7 Alloy"	Cast Iron	Phosphor Bronze
Acetic Acid, 33%	17.0	840	18.6
Boracic Acid, 10%	7.7	57.4	4.6
Citric Acid, 5%	9.3	1,492	4.6
Formic Acid	13.9	138	13.9
Hydrochloric Acid, 1%	32.5	1,007	41.8
Hydrochloric Acid, 5%	54.2	3,360	57.3
Hydrochloric Acid, 20%	62.0	11,180	60.5
Nitric Acid, 1%	620	697	2,446
Nitric Acid, 5%	4,060	4,680	12,420
Nitric Acid, 20%	7,830	10,092	Dissolved
Oxalic Acid, 5%	6.2	55.8	12.4
Phosphoric Acid, 50%	26.4	4,650	7.7
Sulphuric Acid, 1%	26.4	1,642	18.6
Sulphuric Acid, 5%	37.2	6,880	37.2
Sulphuric Acid, 20%	41.8	13,720	38.8
Sulphurous Acid	240	1,032	9.3
Tartaric Acid, 5%	10.8	1,040	10.8
Vinegar	4.6	104	4.6
Acetone	1.5	4.6	1.5
Aluminium Sulphate, 5%	20.0	96.0	10.8
Ammonium Chloride, 5%	10.8	35.6	57.4
Ammonium Nitrate, 5%	51.2	163	57.4
Ammonium Sulphate, 10%	9.3	32.6	13.9
Ammonium Sulphate+5% Sulphuric Acid	26.3	11,160	21.7
Carbon Tetrachloride	1.5	3.0	3.0
Copper Chloride, 10%	1,394	8,030	543
Ferric Chloride, 5%	667	1,038	347
Fuel Oil	1.5	1.5	1.5
Hydrogen Peroxide, 20 vols.	6.2	9.3	1.5
Magnesium Chloride, 10%	7.7	18.6	6.2
Magnesium Sulphate, 10%	3.1	14.0	3.1
Potassium Alum, 10%	15.5	372	20.2
Sea Water	6.2	23.2	6.2
Sodium Chloride, 3%	7.7	12.4	3.1
Sodium Hypochlorite	223	688	80.6
Sodium Sulphate, 5%	9.3	7.7	9.3
Sodium Sulphite, 10%	3.1	6.2	1.5
Sodium Sulphite, 5%	1.5	1.5	17.0

* Kindly supplied by Messrs. Mather & Platt, Ltd.

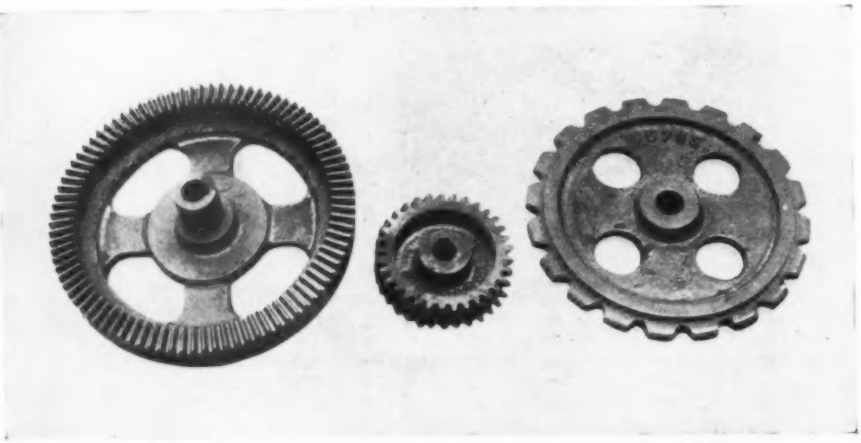


Fig. 5.—Gear Wheels in Austenitic Cast Iron Replacing Bronze.

alloys and, consequently, there are a large number of applications in which the nickel-iron alloys can be considered for the replacement of castings at present made in the latter materials.

A feature of special interest in connection with these alloys is their resistance to erosion when in contact, for example, with mixtures of fluids and solids. In many industrial applications to-day, as, for example, in the hydraulic hand-

Fig. 6. — Test-Pieces of Ordinary and Austenitic Cast Iron after Repeated Heating at 950 deg. C. The Ordinary Cast Iron shows Bad Erosion and Growth, whilst the Austenitic Cast Iron has formed a Thin Hard Oxide Skin.

ling of ash and in the handling of sea water in docks, rapid erosion of pumps and pipes takes place, due to the cutting action of the fine particles of solids suspended in the water. The superiority of the austenitic cast iron over ordinary iron is brought out in the weight loss figures given in Table II.

The heat-resistance of the austenitic cast irons is found to be markedly superior to that shown by the more ordinary material, and the accompanying illustration gives an idea of the attack

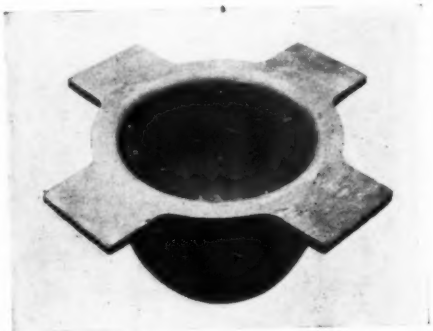


Fig. 7.—Aluminium Melting Pot in Austenitic Cast Iron.

which has taken place on a piece of ordinary iron, as compared with the austenitic iron, after repeated heating at 950 deg. C. Other illustrations show the use of the newer alloys for superheater-tube spacers, in connection with which they have proved very successful, whilst for melting pots handling aluminium and other metals, the austenitic type of iron is proving of great interest.

"Nicrosilal," the alloy recently developed by the British Cast Iron Research Association, is an iron of this class, owing many of its properties to the austenitic condition produced by the high addition of nickel. The abnormally high silicon

in this alloy further enhances the oxidation resistance of the iron.

In many applications in the electrical industries non-magnetic castings are required and, in this connection, the non-magnetic quality of the austenitic irons has proved in the past of great value to the engineer. Many hundreds of tons of non-magnetic castings are used annually in this connection for switch gear, and irons of the "Nomag" type have proved an economic solution of the problem of obtaining these castings in the desired quantities. The electrical and magnetic properties of austenitic cast iron are given in Table IV.

In this table reference is also made to the electrical resistance of the irons and to their low-resistance temperature coefficient, which, coupled with their high resistance, renders them eminently suitable for use as electrical resistance grids.

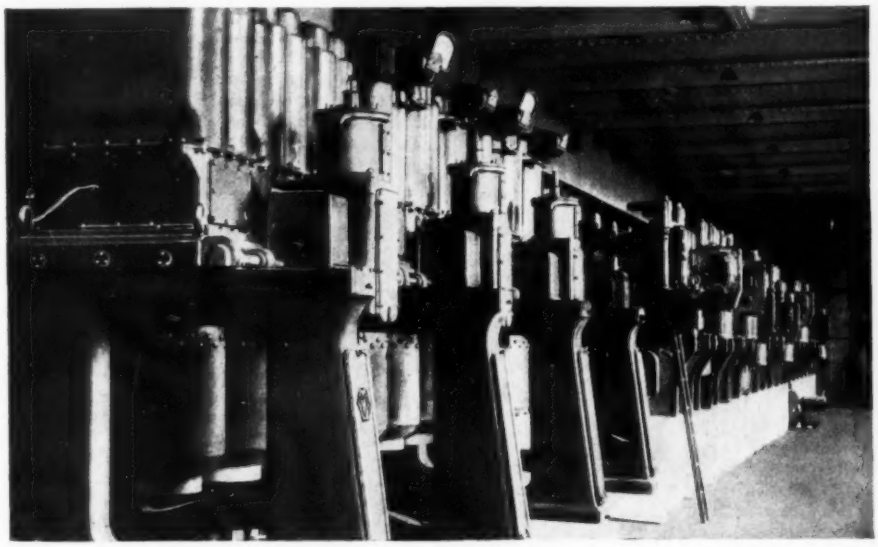


FIG. 8.—SWITCH GEAR IN WHICH NON-MAGNETIC CAST IRON IS USED FOR MOST OF THE CASTINGS.

TABLE IV.—*Electrical and Magnetic Characteristics of an Austenitic Cast Iron.*

Material.	Magnetic permeability maximum.	Specific resistance. Micro-ohms per cm. cube.	Resistance temp. coefficient between 0 deg. C. and 100 deg. C. per deg. C.
"Nomag" (Austenitic cast iron) ..	1.03	150	0.00045
Cast iron	240.00	95	0.0019
Steel (Siemens-Martin)	8,350	18	0.003
Brass (annealed)	approx. 1	7.0	0.002
Pure copper (annealed)		1.59	0.00427
Pure aluminium		2.62	0.00423

FIG. 9.—ELECTRICAL RESISTANCE GRIDS.

The austenitic cast irons show an abnormally high thermal coefficient of expansion. This has been found of value in some applications where the irons are required to operate in conjunction with other high-expansion alloys, such as some of the light alloys. The austenitic types of cast iron have been successfully used in conjunction with aluminium pistons in internal-combustion engines, the similar expansion of the two parts enabling fine clearances to be allowed throughout, with a resultant decrease in troubles such as piston slap.

Finally, details are given in the publication concerning the production of castings in the alloys in the foundry and some notes on their machining quality.

Bengal Iron Company, Limited.

Shareholders of the Bengal Iron Company, Limited, have been notified that the directors expect to issue the accounts for the year ended March 31, 1932, early in August next. They are informed that, owing to the continued world depression in the iron trade, the result for the year, after providing for debenture interest, will show a substantial loss. Drastic economies have been made, it is stated, the full benefit of which will only accrue in the current year. The blast furnaces still remain closed and the demand for pig-iron is at a very low ebb. The foundries have been fairly busy during the last year, but owing to continued restriction of buying by the railways, the sleeper foundry is short of work. Last month, however, some fair orders were booked for castings. The output of the collieries is well sold forward, and two batteries of coke ovens are making coke for outside orders.

Electricity Generation in Great Britain.—The official returns to the Electricity Commissioners show that 987,000,000 units of electricity were generated by authorised undertakers in Great Britain in April, an increase of 13.7 per cent. on April, 1931. During the first four months of 1932 the total amount of electricity generated by authorised undertakers was 4,372,000,000 units, an increase of 7.6 per cent. on 1931.

The Shape of the Tensile Test-Bar for Cast Iron.*

By J. G. PEARCE, M.Sc., M.I.E.E.

The standard tensile test-bar for cast iron in Great Britain is that given in B.S.I. (formerly B.E.S.A.) Specification No. 321—1928, and is illustrated in Fig. 1. The parallel section C, machined down for the purpose of the tensile break, is 2 in. long, and this is the same for bars of all diameters covered by the specification. The question arises as to whether this length is strictly necessary. The form of bar adopted was undoubtedly influenced by that used in standard tests on steel, where the elongation over a measured gauge length has to be taken. In the majority of cast-iron tests, no elongation is specified or required, and there are obvious advantages in reducing or eliminating this length if it can be shown to be unnecessary. The test-piece becomes shorter, easier to mould and cast, and cheaper to machine. Some people fear that an unduly low-test figure would be recorded if a flaw existed in the bar at the point at which fractures were compelled to take place, using a bar without a gauge length. It is, however, difficult to see how the existing bar would be a greater advantage in these circumstances. As far as blow-holes are concerned, the tensile strength of a bar containing blow-holes is often found to be not less and sometimes more than a sound bar of similar material.

TABLE I.—*Influence of Gauge Length on Tensile Strength.*

Test.	Gauge length in.	Grip length in.	M.S. tons/sq. in.	Average M.S. tons/sq. in.
A1	2	3.0	16.20	
A2	2	2.5	16.88	
A3	2	2.0	17.80	16.98
A4	2	1.5	16.60	
A5	2	1.0	17.40	
B1	1	3.0	16.80	
B2	1	2.5	17.12	
B3	1	2.0	16.30	16.96
B4	1	1.5	16.80	
B5	1	1.0	17.80	
C1	nil	3.0	15.80	
C2	nil	2.5	17.50	
C3	nil	2.0	17.20	17.01
C4	nil	1.5	16.80	
C5	nil	1.0	17.74	

In America and Germany a definite move has taken place towards the use of a shorter bar, in America with a short, and in Germany without a parallel length. Both these standards are illustrated with the British bar for comparison in a photograph in a Paper by Dr. H. W. Swift.[1] Mr. A. C. Vivian[2] has suggested that when a cast-iron tensile test-piece is loaded the load is taken by the outer fibres only, and that the load

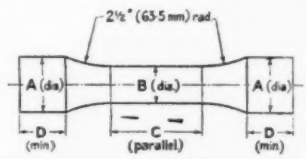


FIG. 1.—INDICATES DIMENSIONS OF EXPERIMENTAL TEST-BARS.

is transmitted to the centre by shear, unless the parts of the specimen are long compared with the diameter. He adds, that the parts of cast-iron bars above 0.5 in. or 0.75 in. dia. are not usually long enough to eliminate this shear effect, which reduces the apparent tensile length. Before Mr. Vivian's Paper was published, the

(*Concluded on page* 330.)

* Reprinted from the B.C.I.R.A. Bulletin, vol. 3, No. 10.
1 FOUNDRY TRADE JOURNAL, March 24, 1932, page 188.
2 FOUNDRY TRADE JOURNAL, January 28, 1932, page 67.

Stalemate in Non-Ferrous Scrap.

TRADING DIFFICULT AT LOW PRICES.

(From a Correspondent.)

One of the most noteworthy aspects of the non-ferrous metal situation is the growing difficulty in trading in old material, especially copper and copper-bearing alloys, whether brass or gun-metal. For the most part dealers are not carrying big stocks, and although demand is not too good they are finding it difficult to satisfy inquiries and at the same time to cover these sales. Consumers are showing an increasing readiness to take advantage of the low prices at present ruling, but scrap-metal merchants are loath to deplete their holding without being able to replenish, and this, owing to the attitude adopted by primary holders, is very difficult, if not impossible. These people, after watching the disastrous slump of the last few months and selling out a proportion of their holding on a falling market, now seem to have made up their minds that nothing can be lost by further waiting, and are evidently determined to await that turn for the better which in their opinion cannot be much longer delayed.

The comparative steadiness of copper and the recent recovery in tin and spelter values lends support to this view, and have provided an encouragement to mark time and live for the future rather than on the proceeds of the present. The adoption of this view cannot occasion any surprise, for prices offered for old metals are now so low that to hold on to the material is no great hardship. Moreover, consumers have latterly displayed a certain amount of eagerness to get in at rock-bottom prices, and for this very reason holders have smelt a rat and determined to sit tight. Low-grade residues are very difficult to handle for a somewhat different reason, for here we find that the man in possession is willing enough to sell, but treatment is not a paying proposition at such low prices as we have to-day, and it therefore becomes almost impossible to treat for recovery of the metal contents at a profit. This business in residues has been an important one, and dealers and merchants are in many cases finding it difficult to carry on in such circumstances.

Since Britain went off gold and the exchanges moved against this country the importation of scrap from America and the Continent has virtually ceased, although from time to time the States have made spasmodic offers at low prices which have been quickly snapped up by consumers or dealers here. In terms of the depreciated £ the return to sellers abroad for scrap sold at the levels ruling here is a very poor one, and such business as has been arranged must be regarded as the outcome of "distress" offers from the other side and is not in sufficient volume to persuade sellers here to unload their stocks. This question of reserves is a somewhat hotly-debated subject, for while some people hold that stocks are piling up owing to the unwillingness of owners to let go at ruling prices, there are others who maintain that trade has been bad for so long that any large accumulation is impossible. In certain directions very fair stocks probably exist, and where these have been held for some time the probability is that in the initial stages of a rise in virgin-metal values practically nothing would be released for consumption, since it is the policy of such holders to try to recoup their losses. Most dealers and merchants in scrap metals have very little stuff on hand, and although they would probably most of them like to get some length, they find it very difficult to do this and at the same time to keep up their turnover.

With scrap so scarce and values so low it says something for the trade that quality has been, on the whole, well maintained, and disputes kept down to a minimum. Where cut-and-dried specifications are lacking some differences of opinion between buyer and seller must inevitably arise, but these are neither frequent nor as a rule serious, and with a little give and take on both sides the trouble can be adjusted. For all that the slump in non-ferrous metals has brought serious hardships to all those connected with scrap, and an upward turn would be welcomed on all sides.

Brinell Hardness and Tensile Strength of Cast Iron.

Mr. J. G. Pearce, M.Sc., M.I.E.E., writing in the April Bulletin of the British Cast Iron Research Association, again refers to the question of the relationship between Brinell hardness and tensile strength of cast iron which periodically arises, on account of the obvious convenience of being able to calculate tensile strength from a Brinell reading. Such ratios, he states, have been used for steel and other materials with success, and formulæ have been proposed from time to time, mainly by Continental metallurgists, for enabling this conversion to be made for cast iron. Mr. Pearce has previously shown* that however sound these formulæ might be for a particular cast, they have no general use, and that the publication of such a formula might, in fact, be misleading.

An opportunity recently arose of comparing Brinell figures with tensile strengths of a series of about 25 engineering irons of good quality, made by a number of members. Made from ordinary cupola-melted metal in the ordinary way for commercial purposes, they were cast into standard bars, 0.875-in., 1.2-in., 1.75-in. and 2.2-in. dia., and standard tensile tests were taken. Brinell tests were made on the shank of each tensile bar, the figure being the mean of three in each case.

The results for any one cast show a general relationship, for as the size of the bar diminishes, the hardness and tensile strength increase. The casts, however, vary very much among themselves. For a cast showing the lowest hardness figures, the relationship was approximately

$$\text{Tensile strength} = \frac{\text{Brinell hardness}}{8} - 11.5.$$

For a cast showing the highest hardness figures, the relationship was approximately

$$\text{Tensile strength} = \frac{\text{Brinell hardness}}{8} - 17.5.$$

Between these extremes other irons are scattered. At one extreme an iron of tensile strength in the various thicknesses of from 10 to 15 tons might have a Brinell range from 182 to 212, whereas at the other extreme an iron of the same range of tensile strengths might have a Brinell range from 220 to 260. In between these extremes figures for other casts would be scattered. These results refer in every case to machinable grey irons. It is evident that no specification could be adopted giving tensile strength in terms of Brinell hardness. Equally, there is no relation between hardness and machinability, or between hardness and abrasive wear.

Iron and Steel Representatives for Ottawa.

Representatives of the iron and steel industry are to go to the Ottawa Conference. The delegation will be led by Mr. A. J. Grant, managing director of Messrs. Thomas Firth & John Brown, Limited, Sheffield, and President of the National Federation of Iron and Steel Manufacturers. He will be accompanied by Sir William Larke (director of the National Federation) The delegation is not quite complete, but it has been decided that the following will be members :—Mr. Julian Piggott (British Steel Export Association), Mr. F. Smith (Templeborough Rolling Mills, Limited), Mr. George Smith (the Firth Company, Limited), and Mr. Geoffrey Summers (John Summers & Sons, Limited).

* B.C.I.R.A. Bulletin, No. 10.

Foundry Opportunities in the West Indies.

Mr. J. L. Wilson Goode, in his Official Report to the Board of Trade on the Economic Conditions in the British West Indies, published by the Department of Overseas Trade, states that a demand exists throughout the British West Indies for internal-combustion engines, particularly in connection with the sugar industry both for field and factory purposes, and to a small extent for use in the estate houses. There is also a demand for internal-combustion engines in connection with public utilities and certain minor industries. In Trinidad, the demand is greater in consequence of the requirements of the oil and asphalt industries; gasolene and Diesel oil of local production are available as well as gas trapped from the Trinidad oil wells. There are no statistics available relating to the exclusive importation of internal-combustion engines, but, broadly speaking, there are in the British West Indies more gasolene engines (including domestic lighting sets for country houses) of American manufacture than of United Kingdom manufacture, but as regards heavy-oil engines the productions of the United Kingdom predominate. Other paragraphs of interest to the foundry industry relate to agricultural machinery, cast iron, hollow-ware, stoves, enamelware and sanitary fittings.

Agricultural Machinery.—Caterpillar tractors of two, four, five and ten tons are used on most of the sugar estates and on some of the more important, where the land is fairly level (notably in British Guiana), steam-cable ploughing plant, consisting of two sets of compound engines, equipped, in some instances, with a three-furrow anti-balance plough, is employed. During the year 1931 a Diesel "Gyrotiller" of United Kingdom manufacture was imported into Antigua in connection with the sugar industry. It introduces an entirely new and greatly improved method of obtaining an unsually high degree of tilth in preparing the soil for planting crops. Silos, irrigation centrifugal pumps, light-disc harrows and cultivators are also in use.

Cast Iron and Hollow-ware.—Certain lines, which are peculiar to tropical countries, are practically all obtained from the United Kingdom. The pre-war demand for competitive articles from Germany and Belgium scarcely exists.

Stove Grates.—The demand for Scottish stoves is a regular one, which is developing slowly but surely. The large local demand is for oil stoves, prominent among which is the American "Perfection" stove, which is distributed among local retailers by the largest American oil company. Among the native population there is a fair demand for United Kingdom oil stoves, except in Bermuda, where German enamel stoves have the largest sale.

Enamelware.—Orders for better class enamelware are placed in the United Kingdom, and occasionally in Sweden. Germany has, however, secured most of the lower-class trade by supplying a general assortment of enamelware articles at a very low cost, but at least one United Kingdom manufacturer is making a bid for the cheap trade, so far successfully. The finish of the United Kingdom and Swedish productions is much superior to that of German enamelware, but price considerations are, with few exceptions, the determining factor in this market.

Sanitary Fittings.—Most of the colonies are participating in the general improvement in sanitation, and, in consequence, the trade in sanitary fittings is increasing. There is a growing demand for fixed lavatory basins instead of movable toilet sets and for enamelled and galvanised sinks for use in kitchen and pantry. Most of the trade has reverted to United Kingdom manufacturers and they should experience no difficulty in meeting competition from other countries.

Babbitting Steel Shell Bearings.

By Robert Jones.

An equipment for metalling or babbitting steel shell bearings is here described, the hatched sections in Fig. 1 showing the babbitt and shaft in position in the steel shell. The cast-iron mandrel without the steel shells is shown assembled in Fig. 2. It is in three separate castings, A, B and C. The reason for making these parts separate is obvious, when considered from the foundry and machinist points of view. The outside diameter D of the centre casting and the bottom faces E require machining, and this can very easily be accomplished in one setting on an ordinary turning and boring mill. The separate castings are also cheaper to make, and the patternmaking is reduced to a minimum.

The cast-iron distance-blocks A and B, identical in design, are simple castings and are conveniently attached to the centre-piece by the bolts F. It will be noticed that the length of the mandrel does not agree with that of the steel shells, but is brought to agree by means of cast-iron loose pieces, Fig. 3. The reason for this is to provide sufficient head metal for feeding the bearing whilst in a molten state and during solidification; this surplus metal is afterwards sawn away.

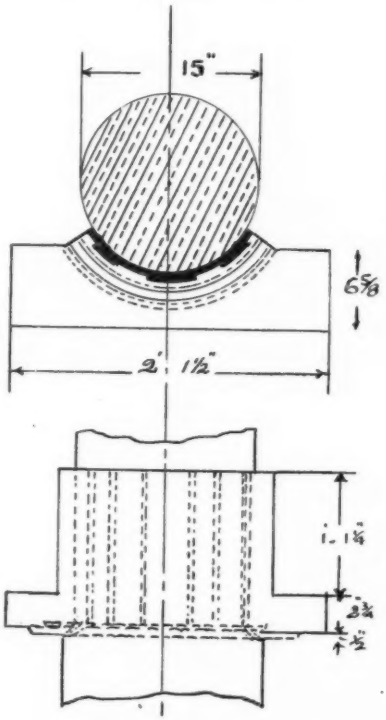


FIG. 1.

Two shells are metalled on one operation. The mandrel, as shown in Fig. 4, is prepared to receive the metal in the following manner. First it is heated to 125 deg. C. and maintained at this temperature, to prevent the chilling of the babbitt. It is also given a thin wash of red clay mixed in water and applied with a brush or swab; this prevents the babbitt sticking to the mandrel, and also prevents blowholes in the babbitt lining. The steel shells are also heated so that the babbitt will flow close to them and both shell and babbitt shrink together.

Both shells are held in position by a very simple clamping device, shown in Fig. 4, made from a steel bar 2½ in. wide by 1 in. thick. This clamp embraces the flanges of both shells and holds them in their respective positions by the two steel wedges A. The whole outfit is enclosed in the foundry floor in well-rammed sand on all sides as shown in Fig. 4. The metal is poured on end, which is the approved practice in this work, and run into both bearings together.

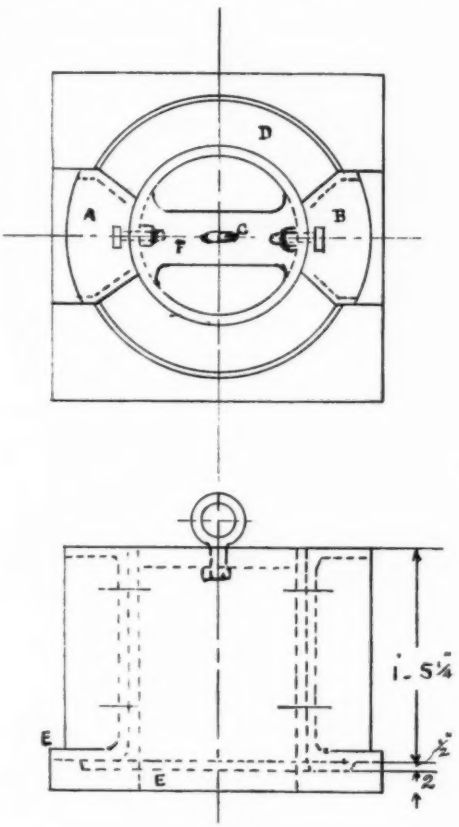


FIG. 2.

Fig. 6 shows in detail, drawn to a scale of 1½ in. to the foot, hard brass studs, cast as shown; four of these studs are driven tight in the dovetail circular recess at the end of the bearings at equal distances, before the metalling is done. These take the end-thrust transmitted by the rolls. These studs have proved a very valuable asset to the life of the bearings.

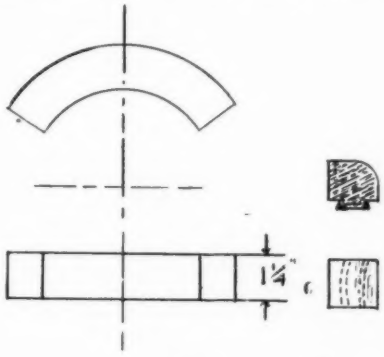


FIG. 3. FIG. 6.

Fig. 5 shows the machine jig used for boring the shells, two at a time. The cast-iron body A is first bored out to (in this case) 19¾ in. as shown, this being the dimension of the outside body of the steel casings. These are held in their respective positions as shown by the four steel

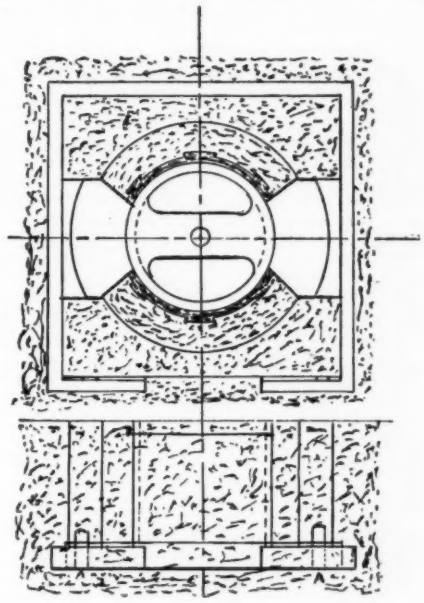


FIG. 4.

studs drilled and tapped in the steel shells. The jig or holder is secured to the boring-mill table

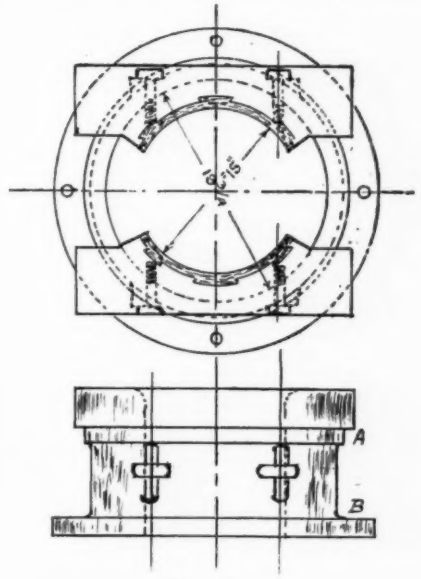


FIG. 5.

in the usual way, four holes in flange B being provided for this purpose.

Institute of British Foundrymen.

NEWCASTLE CONFERENCE.

Members of the Institute of British Foundrymen are reminded of the Annual Conference, which will take place at Newcastle from June 7 to June 10. The programme is very attractive technically, and enjoyable social functions have been arranged. Members who have not booked for the Conference are requested to book immediately through the General Secretary, Mr. T. Makemson, St. John Street Chambers, Deansgate, Manchester.

This Week's News in Brief.

Trade Talk.

After a period of idleness, the Villiers Tinplate Works, Briton Ferry, restarted on May 18, giving employment at four mills to about 200 men.

Messrs. A. B. Kirsop & Company, iron and steel merchants, of 34, West George Street, Glasgow, are removing on May 28 to 166, Buchanan Street, Glasgow.

The Mersey Docks and Harbour Board has accepted the tender of Messrs. Garnock, Bibby & Company, Limited, Liverpool, for the supply of galvanised steel wire ropes.

After having worked regularly since 1926, West Stanley Colliery, owned by the South Derwent Coal Company, Limited, closed down for an indefinite period recently.

Dr. R. Lessing, consulting chemist and chemical engineer, announces that he has moved his laboratory from Horseferry Road, Westminster, and that his consulting practice is now being carried on at 50, Queen Anne's Gate, Westminster, London, S.W.1

The Furness Shipbuilding Company, Limited, of Haverton Hill-on-Tees, has launched the single-screw steam tanker "Britamoco," which has been constructed in twelve weeks. The vessel, which is intended for service on the Canadian Lakes, has a deadweight carrying capacity of 2,800 tons.

The Stirling Boiler Company, of the Babcock & Wilcox, Limited, organisation, Renfrew, has secured an order for the supply of boiler plant for the new electricity super-power station at Fulham. The contract is said to be the largest of its kind to be placed on Clydeside for many months, and it will provide work for the firm's employees over a long period. The whole of the plant will be built at Renfrew.

M. Ostrowsky, a Soviet agent, is at present in Spain studying the possibility of buying Spanish products in exchange for the contract for Soviet petrol signed by the Spanish Finance Minister last year. He is visiting the iron and steel mills and the shipbuilding and other works at Bilbao to see how their prices compare with those of similar manufactures in other countries. It is announced that he contemplates giving orders in Spain for a total of 150,000 tons of rolled iron and steel if satisfactory conditions can be arranged.

An order has been placed with the English Electric Company, Limited, by the Galloway Water Power Company, through their consulting engineers, Messrs. Merz & McLellan, for five large water-turbine alternator sets and three auxiliary sets for the Tongland and Glenlee Power Stations, together with a considerable quantity of switchgear and transformers. The water turbines will be constructed at the company's Rugby works, and form the largest order for this class of product so far undertaken in that factory. The generators and other material will be made at the Stafford works. Other recent orders for power-station plant include a 7,500-kw. turbo-alternator set, a repeat order for a 3,750-kw. set, and a 900-kw. pass-out turbo-alternator, all for industrial concerns in the South of England. The total value of these contracts approximates to £350,000.

Contracts Open.

Egypt, June 15.—Electrically-driven fuel oil pumping set, for the Mechanical and Electrical Department, Ministry of Public Works, Egypt. The Department of Overseas Trade. (Reference G.X. 11,490.)

Horta, June 2.—1,200 water meters, for the Administrative Commission of the Municipal Chamber of Horta. The Department of Overseas Trade. (Reference G.X. 11,451.)

Pensarn, June 13.—Electric pumping machinery, for the Abergele and Pensarn Urban District Council. Mr. R. Green, 37, Bennett's Hill, Birmingham. (Fee £3 3s., returnable.)

Wellington, Salop, June 6.—Pumping machinery, for the Urban District Council. Mr. E. Sandeman, 15, Victoria Street, Westminster, S.W.1. (Fee £2 2s., returnable.)

Personal.

Mr. E. H. Nixon has been elected a director of Messrs. G. A. Harvey & Company (London), Limited.

Mr. A. B. Winder, general manager and a director of Industrial Steels, Limited, has been appointed works director of the English Steel Corporation, Limited

Mr. A. Dunbar, commercial manager of the Elswick works of Messrs. Vickers-Armstrongs, Limited, has been appointed commercial manager of the English Steel Corporation, Limited.

Will.

Marr, J. L., of Sunderland, managing director of the Sunderland Forge & Engineering Company, Limited, and of Sir James Laing & Sons, Limited, shipbuilders £30,309

Obituary.

Mr. Ernest Walter Peake, managing director of Messrs. E. W. Peake, Limited, ironfounders, Slater Street, Liverpool, died last week, aged 56.

Mr. John Frew, employed as a brassmoulder in the works of Messrs. Archibald Low & Company, Merklands Street, Glasgow, collapsed at his bench on May 16 and died almost immediately.

Mr. Joseph M. Hunter, M.I.Mech.E., London manager of the Motherwell Bridge & Engineering Works, Motherwell, died last week. Mr. Hunter was a native of Motherwell, and for a number of years had represented his company in the Metropolis.

Lord Ebury, who died on Sunday, May 15, at the age of 48, was for a period associated with the mining and metallurgical industries. After leaving Harrow in 1899, he studied mining engineering and metallurgical chemistry at the Camborne School of Mines and in London. He worked for a time in mines in the Isle of Man, and then, in 1903, went to Canada, and was employed as metallurgical chemist by the Canadian Pacific Railway Company in British Columbia. He then removed to Nelson, British Columbia, as chief chemist to the Hall Mines. Afterwards, in 1911, he became assistant managing director of the Norton Griffiths contracting firm in Western Canada. He was managing director of the Norton Griffiths interests in British Columbia from December, 1912, till the outbreak of the war.

Mr. Robert Morrison Neilson, a member of the West of Scotland Iron and Steel Institute and of the Institution of Mechanical Engineers, died in Glasgow on May 16. He was well-known in engineering circles in Scotland. Born in 1874, he served his apprenticeship with Messrs. M'Onie, Harvey & Company, engineers, Glasgow, and was afterwards in the employment of Messrs. William Beardmore & Company and Babcock & Wilcox, Limited. For a time he acted as assistant to Prof. Rowden in the Technical College in the teaching of applied mechanics, and also filled the post of Lecturer on Steam and the Steam Engine at the Technical School at Ashton-under-Lyne. Among other appointments he held was that of chief of the technical department at the Hartlepool works of Richardsons, Westgarth & Company. In 1898 he gained a Whitworth Exhibition, and ten years later he took up business in Glasgow as a chartered patent agent.

Company Meeting.

Robey & Company, Limited.

Contracts for Russia were referred to by Mr. W. T. Bell, chairman and managing director of Messrs. Robey & Company, Limited, Lincoln, in presenting the report at the annual meeting at the Globe Works, Lincoln. He said that in pre-war days Russia had been one of the best markets for their products, and the main feature of this year's work had been the carrying out of important contracts for that country. All obligations under these contracts had been most satisfactorily carried out on both sides.

Company Reports.

General Refractories, Limited.—Net profit, £2,240; brought in, £7,323; to depreciation account, £2,500; carried forward, £4,684.

W. H. Baxter, Limited.—Profit, £6,326; brought in, £11,471; dividend of 20 per cent. on the ordinary shares, £9,000; carried forward, £6,667.

Hepworth & Grandage, Limited.—The directors have decided to defer payment of the usual interim dividend until the full year's results are before them.

Whessoe Foundry & Engineering Company, Limited.—The directors recommend a dividend of 7½ per cent. in respect of the year to March 31, 1932.

Manganese Bronze & Brass Company, Limited.—Trading profit, £14,098; brought in, £893; to depreciation reserve, £3,288; net profit, £2,295; carried forward, £3,188.

Tweedales & Smalley (1920), Limited.—Loss of £15,830, which has been deducted from the sum brought in, leaving a balance of £45,022, which the directors propose to carry forward.

The Shape of the Tensile Test-Bar for Cast Iron.

(*Concluded from page* 327.)

writer, in 1931, made a series of tests to ascertain whether a reduction of this grip length (D in Fig. 1) and gauge length (C in Fig. 1) would influence the tensile result. D is 1-in. minimum in the specification.

A series of standard 1.2-in. bars was taken, cast in a good engineering iron of the following analysis: Total carbon, 3.09; silicon, 1.68; manganese, 1.23; sulphur, 0.09, and phosphorus, 0.53 per cent. Fifteen test-pieces were prepared in each of three series, A, B, C. In series A the standard gauge length of 2 in. was used, in each of five grip lengths, from 3 in. to 1 in. in steps of 0.5 in. In series B a gauge length of 1 in. was employed in each of the same five grip lengths. In series C there was no gauge length, the standard shoulder radii meeting in the centre of the test-piece and giving a bar diminishing to the centre without a parallel length. All bars were machined to the standard diameter, 0.798 in. The results are given in Table I.

The following conclusions will be noted:—

(1) There is no regular variation in strength with grip length. The slight differences which occur between the bars of the same series are not regular, so that strength is unaffected by grip length.

(2) There is no regular variation in strength with gauge length. The average strength in each series is almost exactly 17 tons, in spite of changes in the gauge length, so that strength is apparently unaffected by gauge length.

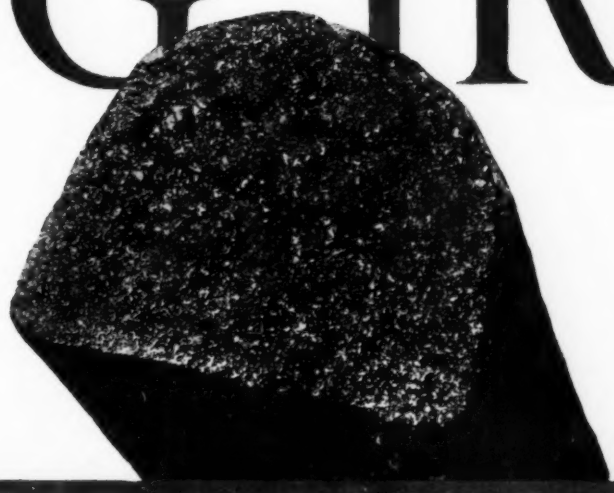
(3) Apart from C1, which is low, the range of variation from the average is very much the same in each series. The variation from the overall mean of 16.98 tons per sq. in. is from 7 per cent. below (the case of the low C1 figure) to 4.8 per cent. above. Or, excluding C1, the variation is within the range ±5 per cent. In other words, irrespective of changes in grip length and gauge length, the tensile strength is constant to within ±5 per cent., this difference probably arising in the material itself.

(4) It is interesting to note that the mean of the three test-bars having the longest grip length (3 in.) is only 16.26 tons per sq. in.

While too much reliance cannot be placed on a series of tests based on one iron and a limited number of grip lengths and gauge lengths, the above results suggest that the tensile strength of cast iron is independent of grip length and gauge length and consequently that the latter could with advantage be modified in the standard test-piece.

The City office of the Department of Overseas Trade has been removed from 73, Basinghall Street to new accommodation on the second floor at 9-12, Basinghall Street, E.C.2.

PIG IRON



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Raw Material Markets.

Little business is being done in the iron and steel markets, mainly owing to the prevailing inactivity in the consuming industries, whose export trade continues to be hampered by exchange restrictions and import duties. The demand for pig-iron is very limited. Indian and Continental basic iron continue to compete in Scotland and South Wales. Trade remains sluggish in nearly all sections of the finished-steel market.

Pig-Iron.

MIDDLESBROUGH.—Deliveries have now resumed their normal course since the holidays, but little new business has been reported. No great improvement in the demand for pig-iron is likely until the consuming industries begin to feel the full benefit of the tariff. The export market shows no sign of expansion. Prices remain as follow:—No. 1 Cleveland foundry iron, 61s.; No. 3 G.M.B., 58s. 6d.; No. 4 foundry, 57s. 6d.; No. 4 forge, 57s. per ton.

There has been some activity on a small scale in the East Coast hematite market during the week. The daily turnover, however, has not been very large. One good feature of the market is that slightly more business is being done with South Wales. Export sales show no improvement. Mixed numbers remain at 63s. 6d. per ton, with No. 1 quality at 64s. West Coast hematite is mainly going into consumption at the local steelworks, few new orders coming to the furnaces. Bessemer mixed numbers remain at 66s. per ton at works.

LANCASHIRE.—There has been little increase in business since the resumption of work. Users of foundry iron are themselves in too poor a position to buy for anything but immediate delivery. The light-castings foundries, including the textile machinists, are not too badly situated, but they are reported to be using an increasing proportion of machinery scrap, placed on the market through the elimination of redundant plant in the cotton mills. Prices are maintained at 67s. per ton for Derbyshire, Staffordshire and Cleveland No. 3, 65s. 6d. for Northants, 62s. 6d. for Derbyshire forge, from 86s. to 87s. for Scottish foundry, and around 81s. for West Coast hematite, delivered Manchester or equal distance.

MIDLANDS.—Little iron is being taken by the foundries in this area, and much of the make is going into stock. Hardly any forward buying has been noted and the outlook is not encouraging. Quotations remain at 62s. 6d. for Northants No. 3 and 66s. for Staffordshire, Derbyshire and Lincolnshire No. 3, including delivery to Birmingham and Black Country stations.

SCOTLAND.—There is similar inactivity in the Scottish iron and steel markets, where hardly any buying has been witnessed for some weeks. Scottish No. 3 foundry remains at 69s. 6d. per ton f.o.t. furnaces, with a minimum of 2s. 6d. extra per ton for No. 1. No. 3 Middlesbrough is at 56s. 6d. per ton at Grangemouth, with other English irons at about the same figure. There is no competition from the Continent.

Coke.

There has been little change in the situation of the foundry-coke market. New business is scarce, and consumers are only buying to satisfy their immediate needs. Best Durham coke is quoted at 37s. 6d. to 40s. per ton, and Welsh coke at 30s. to 45s., according to grade. The above prices are delivered Birmingham and district.

Steel.

The finished-steel trade remains in a very unsatisfactory condition. Specifications are few and of very miscellaneous character, necessitating frequent changing of rolls. The depression in the shipbuilding and heavy engineering trades is unrelieved, while Continental steel bars continue to compete successfully in the British market. The galvanised-sheet and tinplate trades remain quiet.

Continental semis continue to undercut the home product, but little business is being done owing to the general slackness of trade. Considerable stocks of Continental semis bought before the imposition of the tariff have yet to pass into consumption.

Scrap.

In the Cleveland scrap-iron market there is a marked absence of buying by the foundries and prices are weak. Ordinary heavy cast iron is freely offered at 38s., machinery quality at 40s. and light castings at 34s. per ton. The Midlands market has also shown little movement since the holidays, and the foundries' needs are too limited for them to take advantage of the present low prices. Heavy machinery metal, broken into cupola sizes, is quoted at 47s. 6d. per ton delivered, good heavy pipe and plate scrap at 42s. 6d. delivered and clean light metal at 37s. 6d. delivered. The Welsh and Scottish markets have been practically idle during the last fortnight, and quotations are mostly nominal.

Metals.

Copper.—During the week prices have touched new low levels, Tuesday's standard cash quotation being £27 10s. The Exporters' official quotation for electrolytic is continued at 6.25 cents c.i.f., but Customs metal is now quoted at 5.50 cents c.i.f. Outside offers are reported at 5.375 cents. Even at these low levels there has been very little buying, mainly owing to the inactivity of the consuming industries. The news that the American Senate had approved a tax of 4 cents per lb. on imported copper came as a shock to the London market. Should the tariff be finally passed, it will mean the diversion into Europe of large supplies of copper from Chile, etc., and probably the end of the Producers' Association.

Closing quotations :—

Cash.—Thursday, £28 8s. 9d. to £28 10s.; Friday, £28 to £28 2s. 6d.; Monday, £27 11s. 3d. to £27 12s. 6d.; Tuesday, £27 10s. to £27 12s. 6d.; Wednesday, £27 10s. to £27 11s. 3d.

Three Months.—Thursday, £28 12s. 6d. to £28 13s. 9d.; Friday, £28 2s. 6d. to £28 5s.; Monday, £27 13s. 9d. to £27 15s.; Tuesday, £27 12s. 6d. to £27 15s.; Wednesday, £27 11s. 3d. to £27 12s. 6d.

Tin.—The market continues to lack the support of consumers, and such price fluctuations as occur are mainly due to professional dealing. The industrial depression in the United States and on the Continent shows little sign of alleviation, although consumers in the latter part of the world have shown a slight interest during the last week or so. A meeting of the International Tin Committee was held at The Hague on May 20, when the new output restriction scheme was recommended for the acceptance of the signatory Governments.

Official closing prices :—

Cash.—Thursday, £125 12s. 6d. to £125 17s. 6d.; Friday, £124 15s. to £124 17s. 6d.; Monday, £122 to £122 5s.; Tuesday, £123 to £123 5s.; Wednesday, £123 7s. 6d. to £123 10s.

Three Months.—Thursday, £127 12s. 6d. to £127 15s.; Friday, £127 to £127 2s. 6d.; Monday, £124 to £124 5s.; Tuesday, £125 5s. to £125 10s.; Wednesday, £125 12s. 6d. to £125 15s.

Spelter.—There has been an improvement in the statistical position, the stocks of the Pool showing a gradual decrease. This has had little effect upon the consumptive demand, however, and the market has slowly sagged. The tendency has been slightly upward in the United States, and the East St. Louis quotation is now 2.35 cents per lb. There is an increasing demand in Germany for an import duty on foreign spelter, owing to the crisis in the German producing industry, although resistance is being offered by consuming interests.

Daily fluctuations :—

Ordinary.—Thursday, £12 13s. 9d.; Friday, £12 15s.; Monday, £12 5s.; Tuesday, £12 10s.; Wednesday, £12 2s. 6d.

Lead.—Proposals are being made for the re-establishment of the European selling pool, which was dissolved on the imposition of the British import duty. It will be very difficult to adjust the market to a falling consumption. Messrs. Rudolf Wolff & Company write that "business with consumers is quiet, but at the same time there is no great pressure to sell, and prices will no doubt recover very readily on any indication of an improvement in trade demand."

The week's prices have been :—

Soft Foreign (Prompt).—Thursday, £10 13s. 9d.; Friday, £10 10s.; Monday, £10 6s. 3d.; Tuesday, £10 5s.; Wednesday, £9 18s. 9d.

Applying Foundry Technique to Spun Pipe Manufacture.

(*Concluded from page* 324.)

stood Mr. Allan to say was about 17 ft. He would like to know whether they got any swelling on the casting due to the fact that with the jolting at such a depth the bottom portion of the mould would be considerably harder than the top portion. If a given quantity of sand was used for each mould, was the whole given quantity emptied into the flask or was the machine started to operate and the sand put in gradually while the jolting was taking place? He had had some experience of such matters and was rather curious to know whether, with a depth of 17 ft., they would not obtain somewhere midway or probably about two-thirds of the way up a soft spot when the metal was centrifugally cast. He thought perhaps the strain of the metal would press on the walls and the sand and cause swelling.

Mr. Allan said it was true that the length of the box was not far from 17 ft. On the face of it they might expect trouble due to a harder mould at the bottom than the top. That was obviated by hand-ramming at the top. When they took the hopper off there was a certain amount of loose sand at the top. This was hand-rammed and it made that end fairly firm. As to swells they did get them, but they were not a serious trouble in the ordinary way. They could be controlled perfectly well by controlling the sand. They scarcely ever got swells except in the smaller sizes. He did not think they had ever had trouble with the bigger sizes. In regard to the quantity of sand, he was afraid he had not made his meaning clear. The measured quantity of sand only applied in the sand preparation. It was not a definite quantity for the mould. The feeders above the mould were merely turned on and the stream of sand was pipe-fed.

Mr. J. C. Bell referred to the lecturer's remarks about grinding on the inside of the pipes. He would like to know whether the metal was set from the inside or the outside of the mould. If it was the inside he thought they would get a ring on the inside of the pipe. Was that the cause of the deposits which were grounded out?

Mr. Allan pointed out that the metal solidified from the outside first. The deposit that was ground out was the non-metallic material which always stayed on the inside skin, being light. The grinding arrangement was designed to get rid of that, which it did. The deposit collected at the two ends.

Mr. Bell: Does the inside of the pipe show any crack in any form whatever from the inside?

Mr. Allan replied in the negative. He said that the inside of the piping always had a sort of mottled appearance. Of course, as had been mentioned, there was a certain amount of cooling but it was a very, very thin layer and it merely produced the rather mottled effect.

Mr. Bell asked if it was possible or practicable to make a thinner pipe than class B British standard sand pipe.

Mr. Allan said that the thinner the pipe the more difficult it became to make. The Class B was the thinnest that his firm made. It was possible to make a thinner pipe, but, generally speaking, there was no attraction for his firm in making them. After all, the firm existed largely to sell iron. That was the reason for their plant. He would not like to have a quantity of orders for thin pipes.

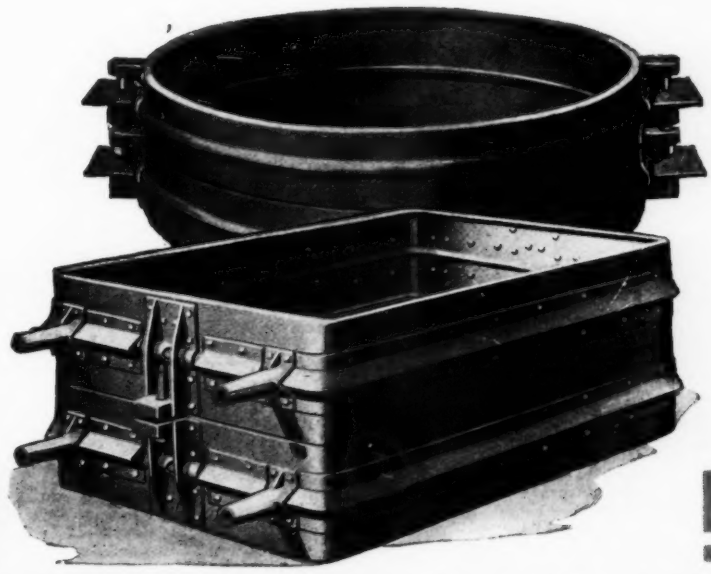
Proposing a vote of thanks, Mr. W. T. Kitching said they were all very grateful to Mr. Allan for giving them such a very interesting lecture. It had not been what he might term too highbrow. That was one reason for it being so interesting. It had been a straightforward description of a plant for making sand-spun pipes.

Service Sterling

SOLID RIBBED ROLLED STEEL
MOULDING BOXES

One of the first steps you should take towards maximum efficiency in your foundry is to install Sterling Moulding Boxes. Those vital qualities lightness, rigidity, strength and accuracy so necessary for the rapid handling of boxes in the modern foundry are the outstanding features of the Sterling Box.

We invite you to prove this statement by allowing us to demonstrate to you how Sterling Boxes can save you money. There are some thirty standard types to meet almost every foundry need. For special purposes our technical staff will gladly design for you the most economical box for your job.



STERLING FOUNDRY SPECIALTIES LIMITED.

London Office:— 13, Victoria Street, S.W.1.

BEDFORD

Agents at:— MANCHESTER. GLASGOW. NEWCASTLE-ON-TYNE.

TELEGRAMS: "STERFLASK, BEDFORD" TELEPHONE. 3345 BEDFORD.

CODE: WESTERN UNION

WEEKLY PRICE CURRENT.

COPPER.

	£	s.	d.
Standard cash	27	10	0
Three months	27	11	3
Electrolytic	31	15	0
Tough	29	10	0
Best selected	30	0	0
Sheets	61	0	0
India	41	10	0
Wire bars	33	10	0
Do., June	33	5	0
Do., July	33	0	0
Ingot bars	33	10	0
H.C. wire rods	36	15	0
Off. av. cash, April	29	19	10¾
Do., 3 mths., April	30	4	0 3/16
Do., Sttlmnt., April	29	19	7½
Do., Electro, April	34	12	10½
Do., B.S., April	33	14	2
Do., wire bars, April	35	1	10½
Solid drawn tubes			9¾d.
Brazed tubes			9¾d.
Wire			6¼d.

BRASS.

Solid drawn tubes	9d.
Brazed tubes	11d.
Rods, drawn	7¾d.
Rods, extd. or rlld.	4¾d.
Sheets to 10 w.g.	7¼d.
Wire	7¼d.
Rolled metal	6¼d.
Yellow metal rods	4¾d.
Do. 4 × 4 Squares	5¼d.
Do. 4 × 3 Sheets	5¾d.

TIN.

	£	s.	d.
Standard cash	123	7	6
Three months	125	12	6
English	124	15	0
Bars	126	10	0
Straits	127	5	0
Australian	124	10	0
Eastern	128	10	0
Banca (nom.)	133	0	0
Off. av. cash, April	109	0	10½
Do., 3 mths., April	111	3	6½
Do., Sttlmt., April	109	0	5½

SPELTER.

	£	s.	d.
Ordinary	12	2	6
Remelted	11	5	0
Hard	9	15	0
Electro 99.9	14	17	6
English	13	0	0
India	11	10	0
Zinc dust	22	0	0
Zinc ashes	2	0	0
Off. aver., April	11	16	3 5/16
Aver. spot, April	11	13	4½

LEAD.

	£	s.	d.
Soft foreign ppt.	9	18	9
Empire	11	0	0
English	12	0	0
Off. average, April	11	7	3½
Average spot, April	11	4	5½

ZINC SHEETS, &c.

	£	s.	d.
Zinc sheets, English	23	0	0
Do., V.M. ex-whf.	20	0	0
Rods	28	0	0
Boiler plates			—
Battery plates			—

ANTIMONY.

	£	s.	d.	£	s.	d.
English	35	0	0 to	42	10	0
Chinese				24	0	0
Crude				16	0	0

QUICKSILVER.

	£	s.	d.
Quicksilver	13	5	0

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro-silicon—	
25%	£8 2 6
45/50%	£13 15 0
75%	£18 17 6
Ferro-vanadium—	
35/50%	12/8 lb. Va.
Ferro-molybdenum—	
70/75% c. free, of Mo.	6/3 per lb.
Ferro-titanium—	
23/25% carbon-free	9½d. lb.
Ferro-phosphorus, 20/25%	£21 0 0
Ferro-tungsten—	
80/85%	2/- lb.
Tungsten metal powder—	
98/99%	2/3½ lb.
Ferro-chrome—	
2/4% car.	£27 17 6
4/6% car.	£25 0 0
6/8% car.	£24 0 0
8/10% car.	£23 15 0
Ferro-chrome—	
Max. 2% car.	£37 10 0
Max. 1% car.	£47 2 6
Max. 0.70% car.	£49 17 6
70% carbon-free	1/1 lb.
Nickel—80/99.5%	£225 to £230
"F" nickel shot	£207 0 0
Ferro-cobalt	8/3 lb.
Aluminium 98/99%	£95 0 0
Metallic chromium—	
96/98%	2/9 lb.
Ferro-manganese (net)—	
76/80% loose	£10 15 0 to £11 5 0
76/80% packed	£11 15 0 to £12 5 0
76/80% export	(nom.) £9 0 0
Metallic manganese—	
94/96% carbon-free	1/4 lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten	2s. 0d.
Finished bars, 18% tungsten	2s. 9d.

Per lb. net, d/d buyers' works.

Extras—

Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 3/16 in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅛ in.	3d. lb.
Do., under ½ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP.

South Wales—	£	s.	d.	£	s.	d.
Heavy steel				2	0	0
Bundled steel and shrngs.	1	17	0 to	1	18	0
Mixed iron and steel	1	15	0 to	1	19	0
Heavy cast iron	2	4	0 to	2	5	0
Good machinery for foundries	2	5	0 to	2	7	6
Cleveland—						
Heavy steel	1	15	0 to	1	17	6
Steel turnings				1	12	0
Cast-iron borings				1	6	0
Heavy forge				2	15	0
W.I. piling scrap				2	7	6
Cast-iron scrap	1	18	0 to	2	0	0
Midlands—						
Light cast-iron scrap				1	17	6
Heavy wrought iron				2	12	6
Steel turnings, f.o.r.				1	0	6
Scotland—						
Heavy steel				1	17	6
Ordinary cast iron				2	2	6
Engineers' turnings				1	9	6
Cast-iron borings				1	10	0
Wrought-iron piling				2	2	6
Heavy machinery				2	7	6

London—Merchants' buying prices delivered yard.

	£	s.	d.
Copper (clean)	25	0	0
Brass	17	0	0
Lead (less usual draft)	8	10	0
Tea lead	6	10	0
Zinc	6	10	0
New aluminium cuttings	72	0	0
Brassery copper	22	0	0
Gunmetal	21	0	0
Hollow pewter	70	0	0
Shaped black pewter	50	0	0

PIG-IRON.

(f.o.t. unless otherwise stated.)

N.E. Coast—	
Foundry No. 1	61/-
Foundry No. 3	58/6
Foundry No. 4	57/6
Forge No. 4	57/-
Hematite No. 1	64/-
Hematite M/Nos.	63/6
N.W. Coast—	
Hem. M/Nos. d/d Glas.	72/-
„ d/d Birm.	84/6
Malleable iron d/d Birm.	117/6
Midlands—	
Staffs common*	—
„ No. 4 forge*	61/-
„ No. 3 fdry.*	66/-
Shrops basic	—
„ Cold blast, ord.	—
„ „ roll iron	—
Northants forge*	57/6
„ fdry. No. 3*	62/6
„ fdry. No. 1*	65/6
Derbyshire forge*	61/-
„ fdry. No. 3*	66/-
„ fdry. No. 1*	69/-
„ basic*	—

*d/d Black Country dist.

Scotland—	
Foundry No. 1	72/-
„ No. 3	69/6
Hem. M/Nos. d/d	68/6
Sheffield (d/d district)—	
Derby forge	58/6
„ fdry. No. 3	63/6
Lincs forge	—
„ fdry. No. 3	63/6
E.C. hematite	75/6
W.C. hematite	83/6
Lancashire (d/d eq. Man.)—	
Derby forge	62/-
„ fdry. No. 3	67/-
Staffs fdry. No. 3	67/-
Northants fdry. No. 3	65/6
Cleveland fdry. No. 3	67/-
Dalzell, No. 3 (special)	102/6 to 105/-
Glengarnock, No. 3	86/- to 87/-
Clyde, No. 3	86/- to 87/-
Monkland, No. 3	86/- to 87/-
Summerlee, No. 3	86/- to 87/-
Eglinton, No. 3	86/- to 87/-
Gartsherrie, No. 3	86/- to 87/-
Shotts, No. 3	86/- to 87/-

FINISHED IRON AND STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

Iron—	£	s.	d.	£	s.	d.
Bars (cr.)	9	12	6 to	9	15	0
Nut and bolt iron	7	15	0 to	8	10	0
Hoops	10	10	0 to	12	0	0
Marked bars (Staffs) f.o.t.				12	0	0
Gas strip	10	10	0 to	12	0	0
Bolts and nuts, ¾ in. × 4 in.				12	0	0
Steel—						
Plates, ship, etc.	8	15	0 to	8	17	6
Boiler plts.	8	7	6 to	9	5	0
Chequer plts.				10	7	6
Angles				8	7	6
Tees				9	7	6
Joists				8	15	0
Rounds and squares, 3 in. to 5½ in.				9	7	6
Rounds under 3 in. to ¾ in. (Untested)	8	12	6 & up.			
Flats—8 in. wide and over				8	12	6
„ under 8 in. and over 5 in.				8	17	6
Rails, heavy	8	5	0 to	8	10	0
Fishplates				12	0	0
Hoops (Staffs)				9	10	0
Black sheets, 24g.	8	0	0 to	8	10	0
Galv. cor. shts.	9	5	0 to	10	0	0
Galv. flat shts.	9	15	0 to	11	0	0
Galv. fencing wire, 8g. plain				12	7	6
Billets, soft	5	7	6 to	5	12	6
Billets, hard				6	12	6
Sheet bars	4	15	0 to	5	7	6
Tin bars				4	15	0

PHOSPHOR BRONZE.

	Per lb. basis.
Strip	10½d.
Sheet to 10 w.g.	11½d.
Wire	11½d.
Rods	10½d.
Tubes	16d.
Castings	12d.

Delivery 3 cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. Clifford & Son, Limited.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	7d. to 1/1
Rolled—	
To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1½ to 1/7½
To 15 in. wide	1/1½ to 1/7½
To 18 in. wide	1/2 to 1/8
To 21 in. wide	1/2½ to 1/8½
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3½
Ingots rolled to spoon size	10d. to 1/6½
Wire round—	
to 10g.	1/4½ to 1/11½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3½ upwards.

AMERICAN IRON AND STEEL.

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	14.84
No. 2 foundry, Valley	15.00
No. 2 foundry, Birm.	11.00
Basic	16.39
Bessemer	17.39
Malleable	17.39
Grey forge	16.89
Ferro-mang. 80%, seaboard	75.00
O.-h. rails, h'y, at mill	43.00
Billets	27.00
Sheet bars	26.00
Wire rods	37.00
	Cents.
Iron bars, Phila.	2.11
Steel bars	1.60
Tank plates	1.60
Beams, etc.	1.60
Skelp, grooved steel	1.60
Skelp, sheared steel	1.60
Steel hoops	1.65
Sheets, black, No. 24	2.20
Sheets, galv., No. 24	2.85
Wire nails	1.95
Plain wire	2.20
Barbed wire, galv.	2.60
Tinplates, 100-lb. box	$4.75

COKE (at ovens).

Welsh foundry	22/- to 27/6
„ furnace	16/6 to 18/-
Durham and Northumberland—	
„ foundry	21/- to 25/-
„ furnace	13/- to 13/6
Midlands, foundry	—
„ furnace	—

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. cokes	20×14 per box		14/6 to 15/-
„	28×20 „		29/- to 30/-
„	20×10 „		—
„	18¾×14 „		—
C.W.	20×14 „		—
„	28×20 „		—
„	20×10 „		—
„	18¾×14 „		—

SWEDISH CHARCOAL IRON & STEEL.

Pig-iron	£6 0 0 to £7 0 0
Bars, hammered, basis	£16 10 0 to £17 0 0
Bars and nail-rods, rolled, basis	£15 17 6 to £16 5 0
Blooms	£10 0 0 to £12 0 0
Keg steel	£32 0 0 to £33 0 0
Faggot steel	£18 0 0 to £23 0 0
Bars and rods dead soft, st'l	£10 0 0 to £12 0 0

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 18.16 to £1.]

DAILY FLUCTUATIONS.

Standard Copper (cash).

		£	s.	d.		
May	19 ..	28	8	9	inc.	3/9
,,	20 ..	28	0	0	dec.	8/9
,,	23 ..	27	11	3	,,	8/9
,,	24 ..	27	10	0	,,	1/3
,,	25 ..	27	10	0	No change	

Electrolytic Copper.

		£	s.	d.		
May	19 ..	32	0	0	dec.	15/-
,,	20 ..	32	0	0	No change	
,,	23 ..	31	15	0	dec.	5/-
,,	24 ..	31	15	0	No change	
,,	25 ..	31	15	0	,,	,,

Standard Tin (cash).

		£	s.	d.		
May	19 ..	125	12	6	inc.	85/-
,,	20 ..	124	15	0	dec.	17/6
,,	23 ..	122	0	0	,,	55/-
,,	24 ..	123	0	0	inc.	20/-
,,	25 ..	123	7	6	,,	7/6

Tin (English ingots).

		£	s.	d.		
May	19 ..	127	0	0	inc.	80/-
,,	20 ..	126	0	0	dec.	20/-
,,	23 ..	123	5	0	,,	55/-
,,	24 ..	124	10	0	inc.	25/-
,,	25 ..	124	15	0	,,	5/-

Spelter (ordinary).

		£	s.	d.		
May	19 ..	12	13	9	inc.	3/9
,,	20 ..	12	15	0	,,	1/3
,,	23 ..	12	5	0	dec.	10/-
,,	24 ..	12	10	0	inc.	5/-
,,	25 ..	12	2	6	dec.	7/6

Spelter (Electro, 99.9 per cent.).

		£	s.	d.		
May	19 ..	15	10	0	inc.	5/-
,,	20 ..	15	10	0	No change	
,,	23 ..	15	0	0	dec.	10/-
,,	24 ..	14	17	6	,,	2/6
,,	25 ..	14	17	6	No change	

Zinc Sheets (English).

		£	s.	d.		
May	19 ..	23	0	0	No change	
,,	20 ..	23	0	0	,,	,,
,,	23 ..	23	0	0	,,	,,
,,	24 ..	23	0	0	,,	,,
,,	25 ..	23	0	0	,,	,,

Lead (English).

		£	s.	d.		
May	19 ..	12	15	0	No change	
,,	20 ..	12	10	0	dec.	5/-
,,	23 ..	12	5	0	,,	5/-
,,	24 ..	12	5	0	No change	
,,	25 ..	12	0	0	dec.	5/-

AVERAGE MONTHLY PRICES OF STEEL SHIP ANGLES (NORTH OF ENGLAND).

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1897	5 7 6	5 7 6	5 7 6	5 5 0	5 0 0	5 0 0	5 2 6	5 2 6	5 2 6	5 0 0	5 0 0	5 2 6	5 2 5½
1898	5 5 0	5 5 0	5 5 0	5 7 6	5 13 9	5 15 0	5 15 0	5 15 0	5 17 6	6 0 0	6 5 0	6 7 6	5 14 3
1899	6 10 0	6 12 6	6 15 0	6 15 0	6 17 6	6 17 6	7 0 0	7 0 0	7 5 0	7 5 0	7 12 6	7 15 0	7 0 5
1900	7 15 0	8 0 0	8 2 6	8 5 0	8 5 0	8 7 6	8 7 6	8 2 6	8 2 6	8 0 0	7 10 0	7 10 0	8 0 7½
1901	6 15 0	6 12 6	6 5 0	6 0 0	6 0 0	5 10 0	5 15 0	5 17 6	6 0 0	5 17 6	5 17 6	5 15 0	6 0 5
1902	5 12 6	5 10 0	5 10 0	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 7 6	5 11 8
1903	5 6 3	5 6 3	5 7 6	5 12 6	5 12 6	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 0 0	5 8 9
1904	5 0 0	4 17 6	5 2 6	5 5 0	5 5 0	5 5 0	5 5 0	5 5 0	5 0 0	5 0 0	5 0 0	5 5 0	5 2 6
1905	5 5 0	5 7 6	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 12 6	6 2 6	6 12 6	6 12 6	5 14 4½
1906	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	7 2 6	6 13 4
1907	6 17 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	6 12 6	7 0 5	
1908	6 2 6	6 2 6	6 2 6	5 17 6	5 17 6	5 17 6	5 17 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 16 2
1909	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 7 6	5 7 6	5 7 6	5 7 6	5 7 6	5 7 6	5 7 6	5 9 7
1910	5 16 3	5 17 6	5 17 6	6 1 6	6 2 6	6 2 6	6 2 6	6 2 6	6 2 6	6 7 6	6 7 6	6 7 6	6 2 3½
1911	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 9 0	6 7 8½	
1912	6 16 3	6 17 6	6 17 6	7 5 0	7 7 6	7 7 6	7 7 6	7 12 6	7 12 6	7 12 6	7 14 6	7 17 6	7 7 4½
1913	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 11 6	7 7 6	6 15 6	6 7 6	6 2 6	7 8 11½
1914	6 2 6	6 2 6	6 2 6	6 2 6	6 2 6	5 15 0	5 15 0	6 15 0	7 0 0	7 0 0	7 1 3	7 5 0	6 8 7½
1915	7 17 0	8 5 0	8 17 6	9 5 0	9 5 0	9 15 0	9 15 0	9 15 0	9 15 0	9 15 0	10 15 0	10 15 0	9 8 3½
1916	11 3 1½	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6
1917	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6
1918	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6½
1919	11 2 6	13 12 6	13 12 6	13 12 6	17 2 6	17 1 3	17 0 0	17 15 0	17 15 0	17 15 0	17 17 6	18 5 0	16 1 9
1920	19 10 0	20 0 0	21 10 0	22 0 0	23 5 0	24 0 0	24 0 0	24 0 0	24 15 0	24 10 0	24 0 0	24 0 0	22 19 2
1921	22 10 0	20 12 6	19 0 0	17 10 0	17 10 0	16 6 0	14 10 0	14 3 4	13 10 0	11 15 0	10 0 0	9 12 6	15 11 7
1922	9 17 6	10 0 0	10 0 0	10 0 0	10 0 0	9 17 6	9 10 0	8 15 7½	8 14 0	8 12 6	8 12 6	8 12 6	9 7 8½
1923	8 18 1½	9 1 3	9 14 0	10 0 0	10 0 0	10 0 0	9 8 9	9 9 6	9 10 0	9 8 9	9 11 6	9 18 9	9 11 8½
1924	10 0 0	9 18 1½	9 17 6	9 17 6	9 17 6	9 17 2	9 11 3	9 15 0	9 15 0	9 9 4½	9 6 6	9 5 0	9 13 1½
1925	9 2 0	9 0 11½	9 0 0	8 15 9	8 10 3½	8 9 0½	8 6 3	8 2 6	7 19 0½	7 9 0	7 5 0	7 2 6	8 5 5½
1926	7 2 6	7 2 6	7 2 6	7 3 4	7 2 6	7 3 9	7 7 6	7 8 5½	7 9 0	7 12 6	7 16 3	8 0 6	7 7 7½
1927	7 18 9	7 17 6	7 17 6	7 14 8½	7 13 9	7 12 6	7 12 6	7 12 6	7 12 6	7 12 6	7 12 6	7 12 6	7 14 1½
1928	7 12 6	7 14 9	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 16 10½
1929	7 17 6	7 17 6	7 17 6	7 17 6	8 0 6	8 2 6	8 2 6	8 2 6	8 2 6	8 2 6	8 2 6	8 5 0	8 0 10½
1930	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6
1931	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6
1932	8 7 6	8 7 6	8 7 6	8 7 6	—	—	—	—	—	—	—	—	—

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